Morphology

Morphology:

• Remove imperfections introduced during segmentation

Foreground (FG), Background (BG)

Support of Image: the set of foreground pixel locations

The complement of support —> background

SE (Structuring Element) — a small image used as a moving window

Reflected Structuring Elements

$$\widetilde{s}(x, y) = s(-x, -y)$$

is the reflected structuring element.

 \tilde{s} is s rotated by 180° around its origin.

Fitting, Hitting

Fundamental Operations

- Erosion
- Dilation

Erosion

$$f \ominus s$$

$$g(x, y) = \begin{cases} 1 \text{ if } s \text{ fits } f \\ 0 \text{ otherwise} \end{cases}$$

Erosion 作用:

- 1. **Split** joined objects (separate touching objects)
- 2. Strip away extrusions
- 3. Remove small spurious bright spots (salt noise)

Dilation

$$f \oplus s$$

$$f \oplus S$$

$$g(x,y) = \begin{cases} 1 \text{ if } s \text{ hits } f \\ 0 \text{ otherwise} \end{cases}$$

Dilation作用:

- 1. **Repair** breaks
- 2. Repair intrusions
- 3. Remove small spurious holes (pepper noise)

Erosion from Dilation / Dilation from Erosion

$$f \oplus s = f^c \ominus \widetilde{s}$$

Compound Operations

- Opening
- Closing

Opening

$$f \circ s = (f \ominus s) \oplus s$$

Closing

$$f \bullet s = (f \oplus s) \ominus s$$

Morphological Algorithms

- Boundary extraction
- · Region filling

Boundary Extraction (2)

$$\beta(A) = A - (A \ominus B)$$

$$(A \oplus B) - A$$

Region Filling

$$X_k = (X_{k-1} \oplus B) \cap A^c$$
 $k = 1,2,3....$

Xo: simple starting point <u>inside the boundary</u>

B: SE

A: the original boundary Stop criteria: until $X_k = X_{k-1}$

Binary reconstruction: used after opening to grow back pieces of the original image that are connected to the opening (not important)

Practice

| This | s question is about Image Morphology. [6 marks] |
|------|---|
| | By using erosion and dilation operators, give the mathematical representation of morphological opening and morphological closing for the structuring element S and image M . |
| | (3 marks) |
| , | By using erosion and dilation operators, give the mathematical representation of morphological inside and outside boundary extraction for the structuring element S and image M . |
| | (3 marks) |
| (1) | Declaration for significances; |
| | o: openniul. |
| | · : closalg |
| | 1. if s was M |
| | (): Eroston gax.y,={1, if s fits M |
| Mo | rphological opening: MOS = (MOS) OS |
| | rphological closing; M·S = (M#S) 05 |
| (2) | BCM) represent the boundary for M: |
| | O ving enosion o : |
| | BCND = M - (MOS) |
| | , |
| | e crack grantes €: |
| | β(M) = (M⊕s) - M |

| c) This question is about Image Morphology. | |
|---|---|
| | [8 marks] |
| Give the mathematical representation of morphological erosion and morp the structuring element S and image M. | phological dilation for |
| the structuring element 5 and image M. | (2 marks) |
| | |
| | |
| ii) Show the relationship between erosion and dilation. | (2 marks) |
| | |
| iii) By using the following structuring element S, apply erosion and dilation M and give the results. | operators to the image |
| [0 0 0 0 0] | |
| $S = \begin{bmatrix} 0 & \textcircled{1} & 0 \\ 0 & \textcircled{2} & 0 \\ 0 & \textcircled{3} & 0 \end{bmatrix}, M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ | |
| | |
| To the time to the | (4 marks) |
| 只靠近正有了的一个人 | |
| | |
| | C Pier N |
| | -s fire M |
| | es fix M Lowise |
| | LS fix M Lowise Ps htm M |
| | Convice Convice Poshes M |
| (1) morphological erosion: $MDS = \begin{cases} 1 & \overline{v} \\ 0 & \text{otherwise} \end{cases}$ morphological dilation: $MDS = \begin{cases} 1 & \overline{v} \\ 0 & \text{otherwise} \end{cases}$ | - S fits M howise P S http: M thereise |
| (1) morphological erosion: $M \Rightarrow S = \begin{cases} 1 & \overline{c}f \\ 0 & \text{otherwise} \end{cases}$ morphological, distation: $M \Rightarrow S = \begin{cases} 1 & \overline{c}f \\ 0 & \text{otherwise} \end{cases}$ | |
| (1) morphological erosion: $MDS = \begin{cases} 1 & \text{if} \\ 0 & \text{oth} \end{cases}$ morphological dilation: $MDS = \begin{cases} 1 & \text{if} \\ 0 & \text{oth} \end{cases}$ (2) The relationship between erosion and | Direcon |
| (1) morphological crosion: MAS = { i of other morphological dilation: MAS = } i of other continues of the relationship between crosion and it is a continued at the continues of | Otherou |
| (1) morphological crosion: MAS = { i of other morphological dilation: MAS = } i of other continues of the relationship between crosion and it is a continued at the continues of | Otherou |
| (1) morphological crosion: Mass = { i of other morphological dilation: Mass = } i of other continues of the relationship between crosion and it is a continued as the continues of the continues | Otherou |
| (1) morphological crosion: MAS = { i of other morphological dilation: MAS = } i of other continues of the relationship between crosion and it is a continued at the continues of | Otherou |
| (1) morphological crosion: MAS = { i of other morphological dilation: MAS = } i of other continues of the relationship between crosion and it is a continued at the continues of | Otherou |
| (1) morphological erosion: MAS = $\begin{cases} 1 & \text{of} \\ 0 & \text{oth} \end{cases}$ morphological dilation: MAS = $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (2) The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (rotation by 1803) Dication with in the complete that complete the complete the complete that complete the complete the complete that complete the complete the complete the complete the complete the c | Otherion ture element 5 the reflected 55 of the complement ment of enosion. The reflected 56 of the complement enems of diletion. |
| (1) morphological erosion: MAS = $\begin{cases} 1 & \text{of} \\ 0 & \text{oth} \end{cases}$ morphological dilation: MAS = $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (2) The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (rotation by 1803) Dication with in the complete that complete the complete the complete that complete the complete the complete that complete the complete the complete the complete the complete the c | Otherion ture element 5 the reflected 55 of the complanent ment of enosion. The reflected st of the complans enemt of dileton. teion: |
| (1) morphological erosion: MAS = $\begin{cases} 1 & \text{of} \\ 0 & \text{oth} \end{cases}$ morphological dilation: MAS = $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (2) The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (rotation by 1803) Dication with in the complete that complete the complete the complete that complete the complete the complete that complete the complete the complete the complete the complete the c | Otherion ture element 5 the reflected 55 of the complanent ment of enosion. The reflected st of the complans enemt of dileton. teion: |
| (1) morphological erosion: MAS = $\begin{cases} 1 & \text{of} \\ 0 & \text{oth} \end{cases}$ morphological dilation: MAS = $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (2) The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (rotation by 1803) Dication with in the complete that complete the complete the complete that complete the complete the complete that complete the complete the complete the complete the complete the c | Otherion ture element 5 the reflected 55 of the complament ment of enosion. Lee reflected st of the complament enemt of dileton. teion: |
| (1) morphological erosion: MAS = $\begin{cases} 1 & \text{of} \\ 0 & \text{oth} \end{cases}$ morphological dilation: MAS = $\begin{cases} 1 & \text{oth} \\ 0 & \text{oth} \end{cases}$ (2) The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The relationship between erosionship between erosion and $\begin{cases} 3 & \text{means} \\ 0 & \text{oth} \end{cases}$ The rel | Otherion ture element 5 the reflected 55 of the complament ment of enosion. Lee reflected st of the complament enemt of dileton. teion: |
| (1) morphological crosion: MAS = $\begin{cases} 1 & \text{if} \\ 0 & \text{oth} \end{cases}$ morphological dilation: MAS = $\begin{cases} 1 & \text{if} \\ 0 & \text{oth} \end{cases}$ (2) The relationship between erosion and $\begin{cases} 1 & \text{if} \\ 0 & \text{oth} \end{cases}$ The relationship between erosion and $\begin{cases} 1 & \text{if} \\ 0 & \text{oth} \end{cases}$ When the reflected of the structure (rotation by 180°) NH S = MC \Rightarrow S \Rightarrow tractor with in the complex of the complex | Otherion ture element 5 the reflected 55 of the complament ment of enosion. Lee reflected st of the complament enemt of dileton. teion: |