Şekilbilimsel Görüntü İşleme

Samsun – 2011

- İkil resim A ve B gibi iki nesne içersin

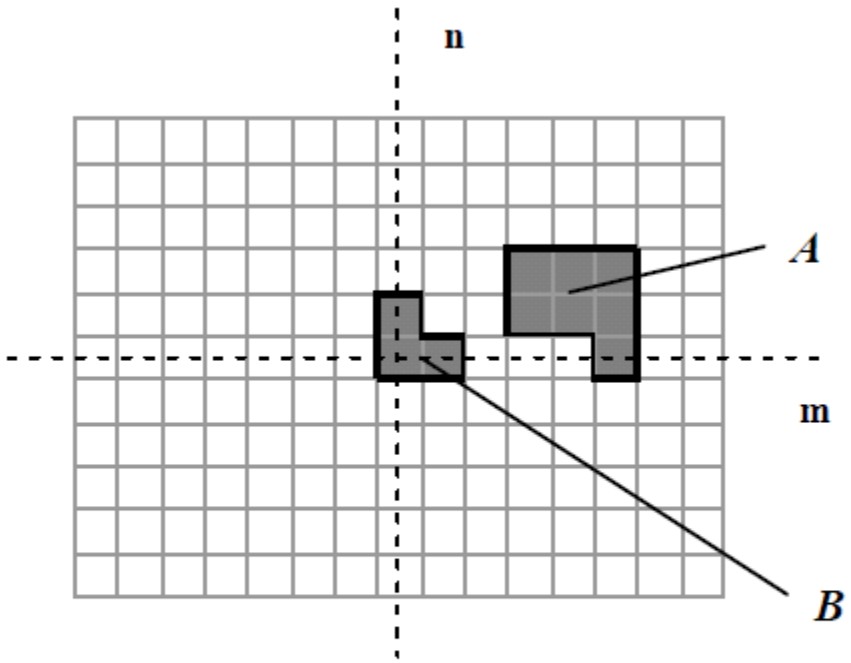


Figure 35: A binary image containing two object sets ***A*** and ***B***.

Başlarken

- Aynı ortak özelliğe sahip olan pikseller

$$A = \{\alpha \,|\, property(\alpha) == \text{TRUE}\}$$

- A'nın dışındakiler – A^c

$$A^c = \{\alpha \,|\, \alpha \notin A\}$$

Tanım

- Nesne ve arkaplan

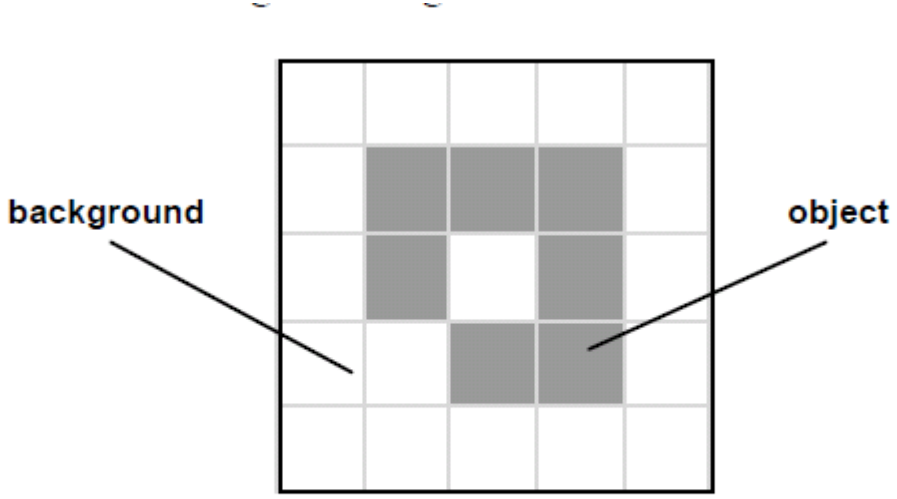


Figure 36: A binary image requiring careful definition of object and background connectivity.

İşlemler

- Kayma $A + \mathbf{x} = \{\alpha + \mathbf{x} | \alpha \in A\}$
- Minkowski toplama $A \oplus B = \bigcup_{\beta \in B} (A + \beta)$
- Minkowski çıkartma $A \ominus B = \bigcap_{\beta \in B} (A + \beta)$

Dilation / Erosion

- Dilation

$$D(A,B) = A \oplus B = \bigcup_{\beta \in B} (A + \beta)$$

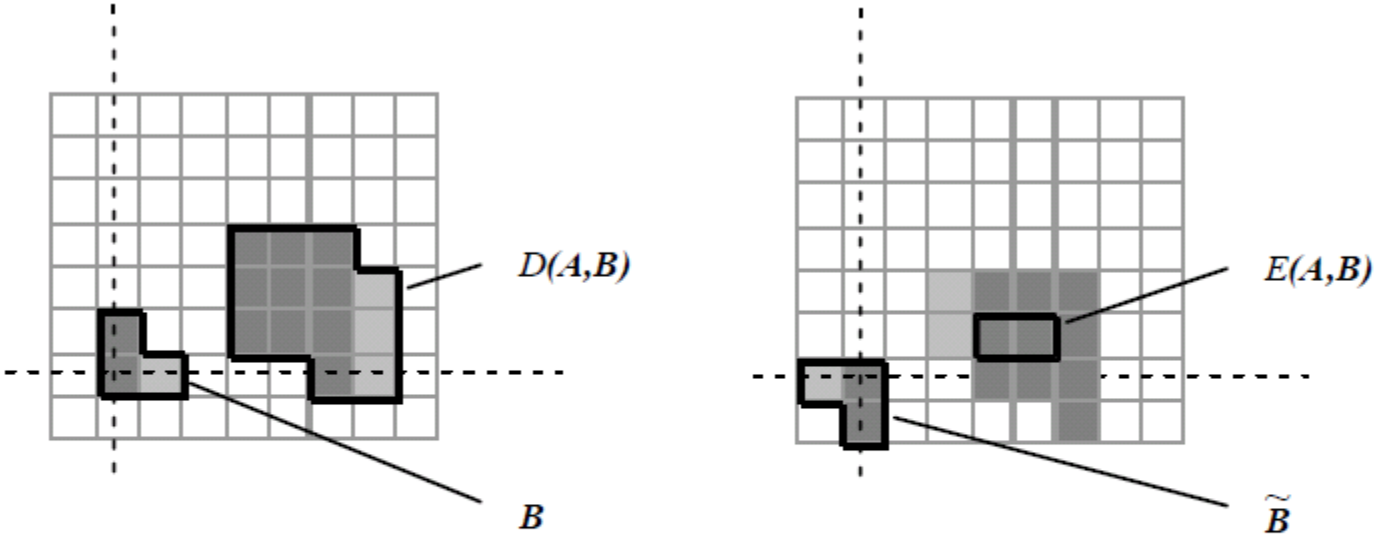
- Erosion

$$E(A,B) = A \ominus \tilde{B} = \bigcap_{\beta \in B} (A - \beta)$$

$$\tilde{B} = \{-\beta \,|\, \beta \in B\}$$

- A: resim ve
- B: yapı elemanı

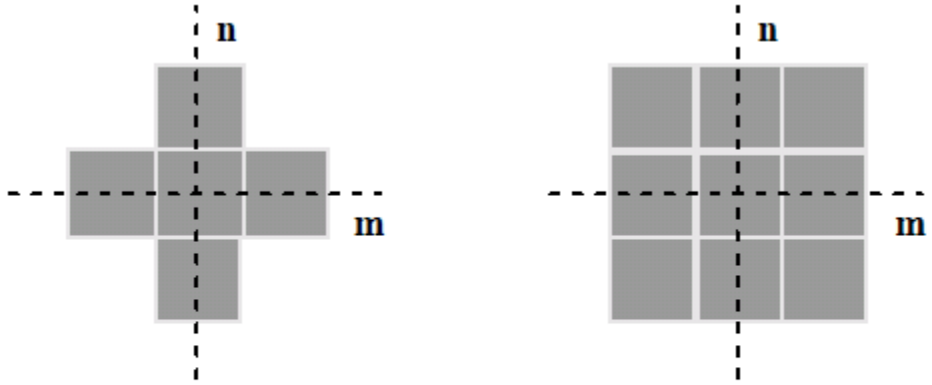
Dilation / Erosion



(a) Dilation $D(A,B)$ **(b)** Erosion $E(A,B)$

Figure 37: A binary image containing two object sets A and B. The three pixels in B are "color-coded" as is their effect in the result.

Yapı elemanı



(a) N_4 (b) N_8

Figure 38: The standard structuring elements N_4 and N_8.

özellikler

Commutative – $D(\boldsymbol{A},\boldsymbol{B}) = \boldsymbol{A} \oplus \boldsymbol{B} = \boldsymbol{B} \oplus \boldsymbol{A} = D(\boldsymbol{B},\boldsymbol{A})$

Non-Commutative – $E(\boldsymbol{A},\boldsymbol{B}) \neq E(\boldsymbol{B},\boldsymbol{A})$

Associative – $\boldsymbol{A} \oplus (\boldsymbol{B} \oplus \boldsymbol{C}) = (\boldsymbol{A} \oplus \boldsymbol{B}) \oplus \boldsymbol{C}$

Translation Invariance – $\boldsymbol{A} \oplus (\boldsymbol{B} + \mathbf{x}) = (\boldsymbol{A} \oplus \boldsymbol{B}) + \mathbf{x}$

Duality –

$$D^c(\boldsymbol{A},\boldsymbol{B}) = E(\boldsymbol{A}^c,\tilde{\boldsymbol{B}})$$

$$E^c(\boldsymbol{A},\boldsymbol{B}) = D(\boldsymbol{A}^c,\tilde{\boldsymbol{B}})$$

Mantıksal Katlama

- A: ikil resim (veya yapı elemanı)

$$A \leftrightarrow \sum_{k=-\infty}^{+\infty} \sum_{j=-\infty}^{+\infty} a[j,k] \bullet \delta[m-j, n-k]$$

- Burada Topla ve Çarp sembolü, mantıksal OR ve AND işlemine denk düşer
- a[j,k] ve dirac[j,k]: 1 veya 0 değeri alabilir

Dilation

$$D(\boldsymbol{A},\boldsymbol{B}) = \sum_{k=-\infty}^{+\infty} \sum_{j=-\infty}^{+\infty} a[j,k] \bullet b[m-j,n-k] = \boldsymbol{a} \otimes \boldsymbol{b}$$

$$D(\boldsymbol{A},\boldsymbol{B}) = \sum_{k=-\infty}^{+\infty} \sum_{j=-\infty}^{+\infty} a[m-j,n-k] \bullet b[j,k] = \boldsymbol{b} \otimes \boldsymbol{a} = D(\boldsymbol{B},\boldsymbol{A})$$

- De Morgan yasasına göre

$$\overline{(a+b)} = \overline{a} \bullet \overline{b} \quad \text{and} \quad \overline{(a \bullet b)} = \overline{a} + \overline{b}$$

Erosion

$$E(\boldsymbol{A},\boldsymbol{B}) = \prod_{k=-\infty}^{+\infty} \prod_{j=-\infty}^{+\infty} \left(a[m-j, n-k] + \overline{b}[-j,-k] \right)$$

- İkil resimler söz konusuysa erosion/dilation, mantıksal cebirde katlamadır

Opening - Closing

- Erosion – dilation kombinasyonu

$$\textit{Opening} - \qquad O(\boldsymbol{A},\boldsymbol{B}) = \boldsymbol{A} \circ \boldsymbol{B} = D(E(\boldsymbol{A},\boldsymbol{B}),\boldsymbol{B})$$

$$\textit{Closing} - \qquad C(\boldsymbol{A},\boldsymbol{B}) = \boldsymbol{A} \bullet \boldsymbol{B} = E(D(\boldsymbol{A},\tilde{\boldsymbol{B}}),\tilde{\boldsymbol{B}})$$

- B^: ayna yansısı

özellikleri

Duality –

$$C^c(\boldsymbol{A},\boldsymbol{B}) = O(\boldsymbol{A}^c,\boldsymbol{B})$$

$$O^c(\boldsymbol{A},\boldsymbol{B}) = C(\boldsymbol{A}^c,\boldsymbol{B})$$

Translation –

$$O(\boldsymbol{A}+\mathbf{x},\boldsymbol{B}) = O(\boldsymbol{A},\boldsymbol{B})+\mathbf{x}$$

$$C(\boldsymbol{A}+\mathbf{x},\boldsymbol{B}) = C(\boldsymbol{A},\boldsymbol{B})+\mathbf{x}$$

Hit – and – Miss işlemi

Hit-and-Miss –

$$HitMiss(\boldsymbol{A}, \boldsymbol{B}_1, \boldsymbol{B}_2) = \begin{cases} E(\boldsymbol{A}, \boldsymbol{B}_1) \cap E(\boldsymbol{A}^c, \boldsymbol{B}_2) \\ \\ E(\boldsymbol{A}, \boldsymbol{B}_1) \bullet E(\overline{\boldsymbol{A}}, \boldsymbol{B}_2) \end{cases}$$

- B1 ve B2 yapı elemanı bağsızdır
- B1 n B2 = 0
- Ör. B1: template, B2: arkaplan

Örnek

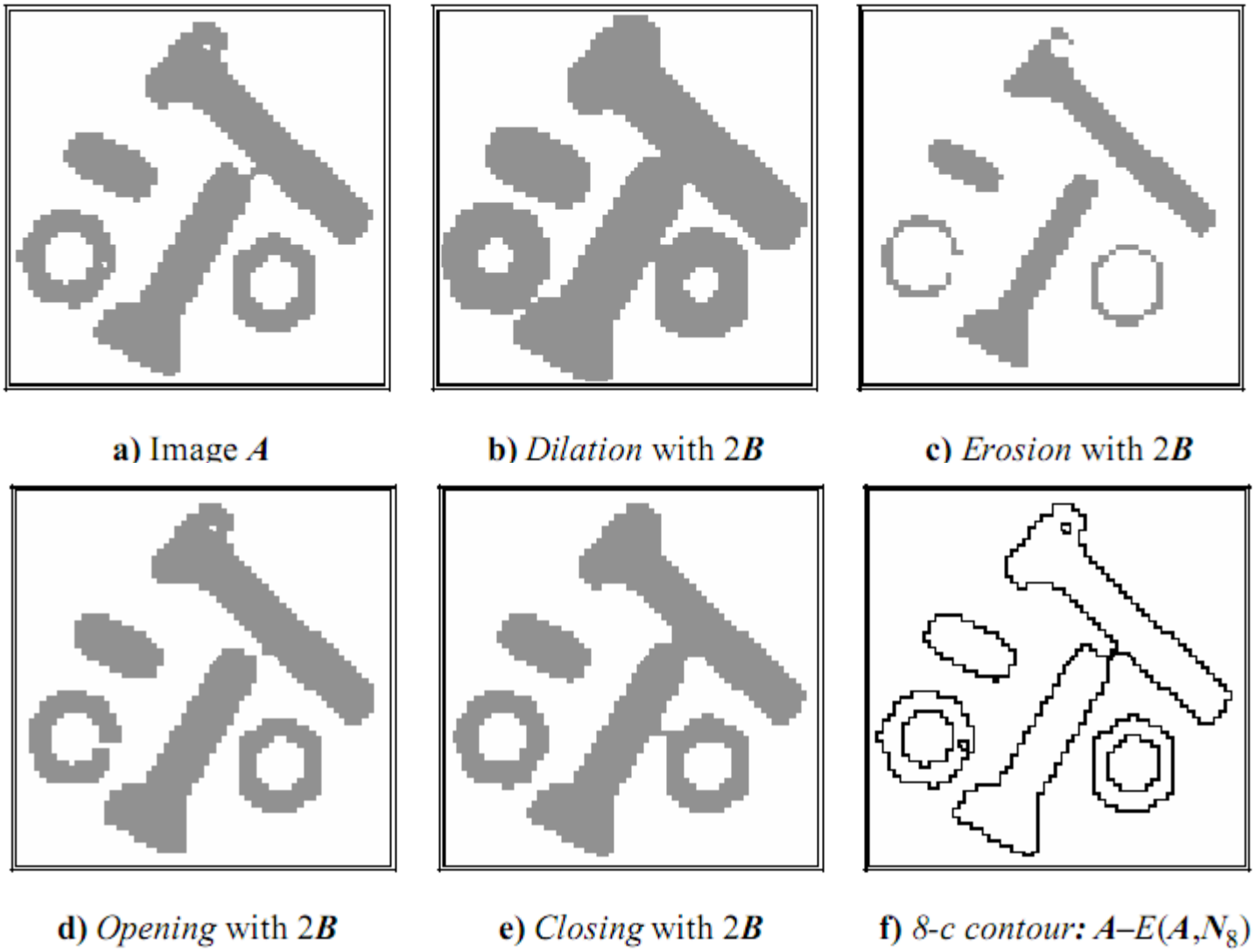
$$B = N_8 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \qquad B_1 = \begin{bmatrix} - & - & - \\ - & 1 & - \\ - & - & - \end{bmatrix} \qquad B_2 = \begin{bmatrix} - & 1 & - \\ 1 & - & 1 \\ - & 1 & - \end{bmatrix}$$

(a) **(b)** **(c)**

Figure 40: Structuring elements B, B_1, and B_2 that are 3×3 and symmet

- Yapı işlevleri simetriktir
- "-": önemsiz (don't care)

Örnek: 1: siyah ve 0: beyaz



a) Image ***A*** **b)** *Dilation* with $2\boldsymbol{B}$ **c)** *Erosion* with $2\boldsymbol{B}$

d) *Opening* with $2\boldsymbol{B}$ **e)** *Closing* with $2\boldsymbol{B}$ **f)** *8-c contour:* $\boldsymbol{A}-E(\boldsymbol{A},\boldsymbol{N}_8)$

Figure 41: Examples of various mathematical morphology operations.

örnek

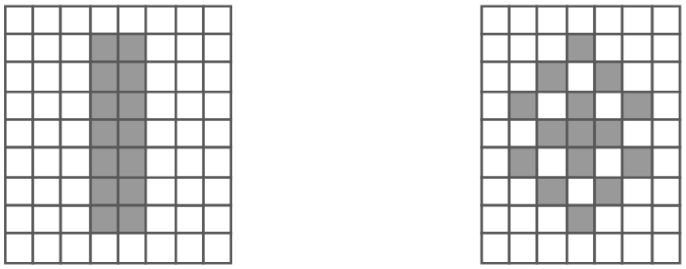
- Opening: nesneleri ayırdı
- Closing: küçük boşlukları doldurdu
- Her iki işlem nesne kontörlerini yumuşattı
  - Opening: nesne kontörünün iç tarafından yumuşattı
  - Closing: nesne kontörünün dışından
- Hit-and-miss: N4 kontör piksellerini verir
  - Alternatif yaklaşım

$$\partial A = A - E(A, N_8)$$

$$\partial A = A - E(A, N_4)$$

İskelet

- Tanım olarak
  - Bir piksel kalınlığa sahip
  - Nesnenin ortasından geçen
  - Nesne topolojisini barındıran çizgidir
- Her zaman karşılanamayabilir



(a) (b)

Figure 42: Counterexamples to the three requirements.

formül

$$\textit{Skeleton subsets} - \quad \boldsymbol{S}_k\left(\boldsymbol{A}\right) = E(\boldsymbol{A}, k\boldsymbol{B}) - \left[E(\boldsymbol{A}, k\boldsymbol{B}) \circ \boldsymbol{B}\right] \quad k = 0,1,\ldots K$$

- Burada K, Sk(A)'nın dolu olmasını sağlayan en büyük k değeridir
- B: yapı elemanı, genelde dairesel
- İskelet ise,

$$\textit{Skeleton} - \quad \boldsymbol{S}\left(\boldsymbol{A}\right) = \bigcup_{k=0}^{K} \boldsymbol{S}_k\left(\boldsymbol{A}\right)$$

Thinning

- Alternatif yol, inceltmeyi hit-and-miss ile yapmak

$$Thinning - \qquad Thin(\boldsymbol{A}, \boldsymbol{B}_1, \boldsymbol{B}_2) = \boldsymbol{A} - HitMiss\left(\boldsymbol{A}, \boldsymbol{B}_1, \boldsymbol{B}_2\right)$$