



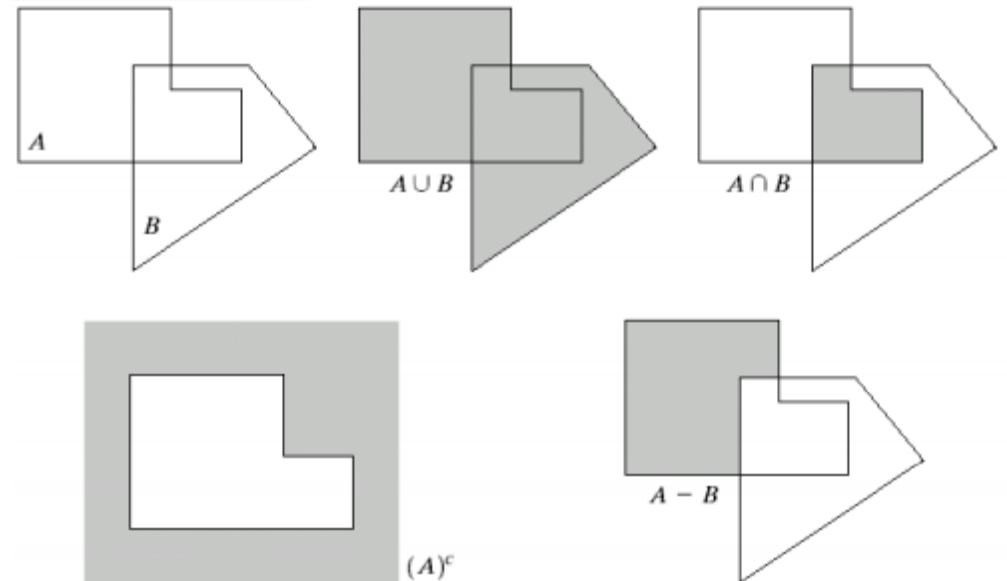
Processamento Morfológico de Imagens

Tópicos Especiais em Engenharia de Computação

Cesar Albenes Zeferino e Felipe Viel

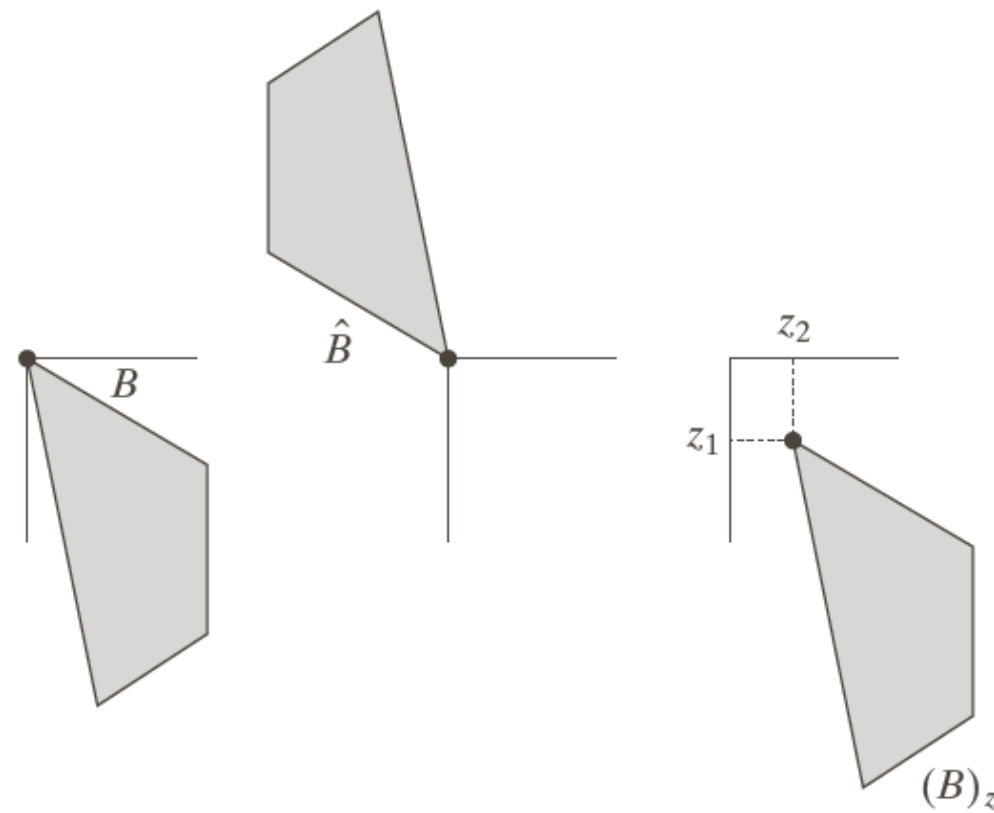
Introdução

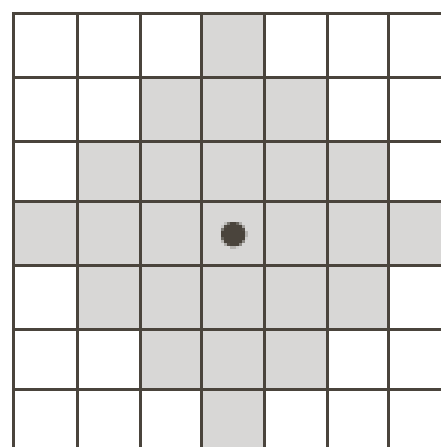
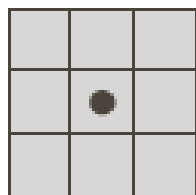
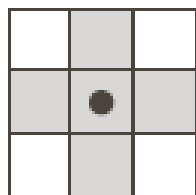
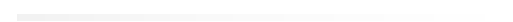
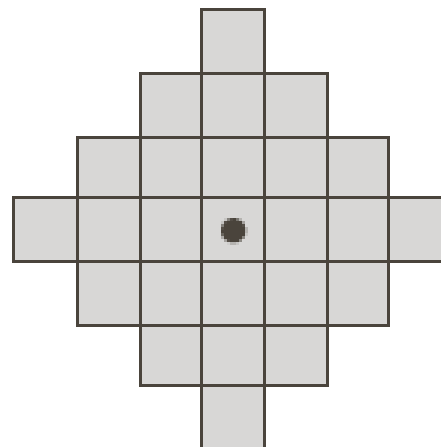
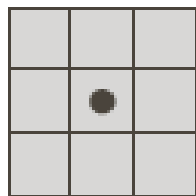
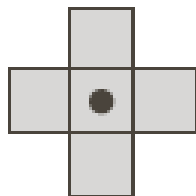
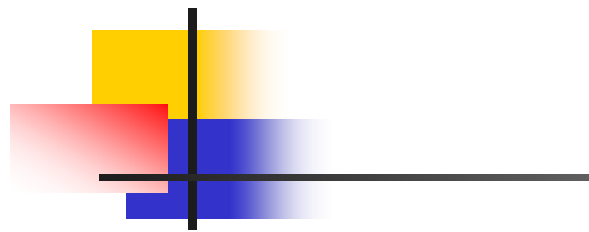
- Ferramenta para extrair componentes das imagens que são úteis na representação e na descrição da forma de uma região
- Teoria dos Conjuntos
- Entrada são imagens e as saídas são atributos extraídos das imagens

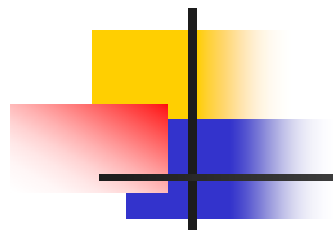


9.1 Definições básicas

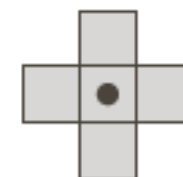
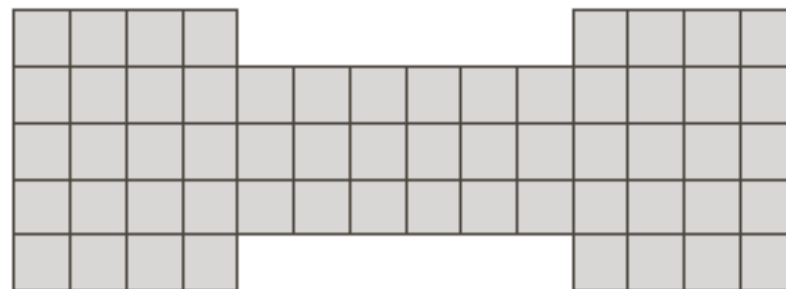
- Dado B como um conjunto de pixels
- Então a rotação é simplesmente o conjunto dos pontos em B cujas coordenadas (x, y) foram substituídas por $(-x, -y)$
- A translação é dada pelas coordenadas (x, y) que foram substituídas por $(x + z_1, y + z_2)$



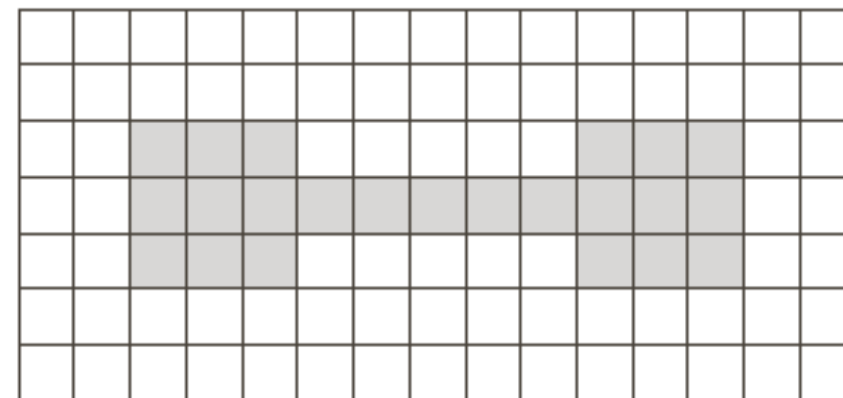
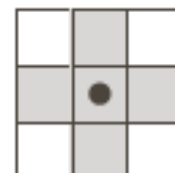
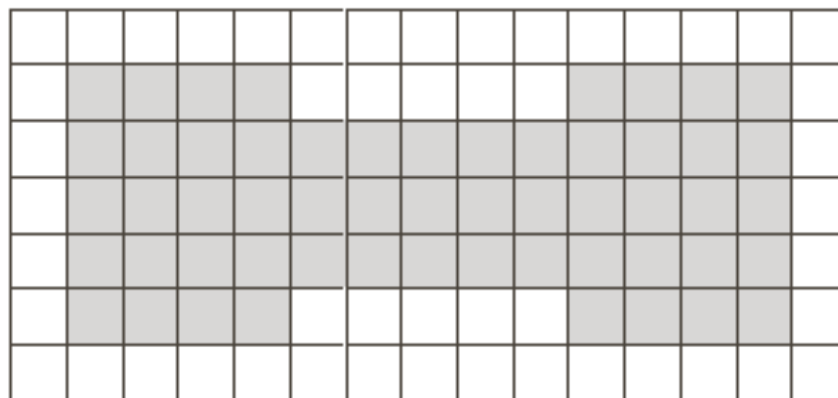




A



B

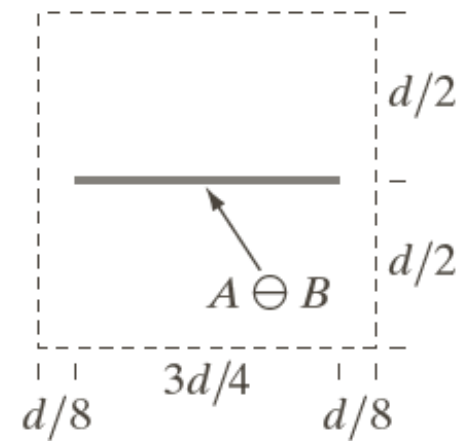
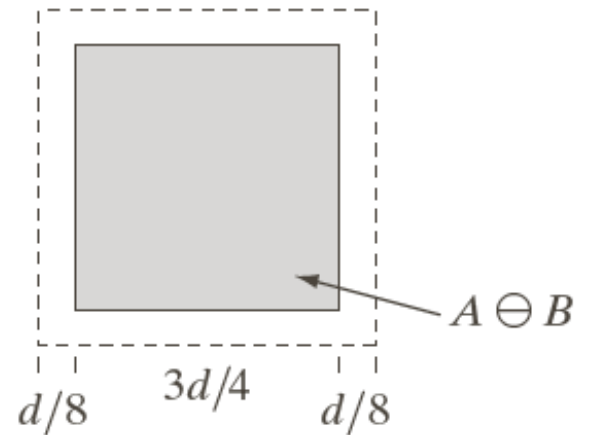
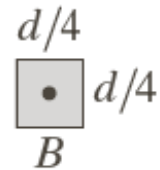
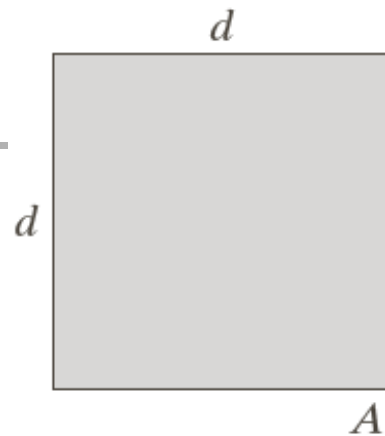


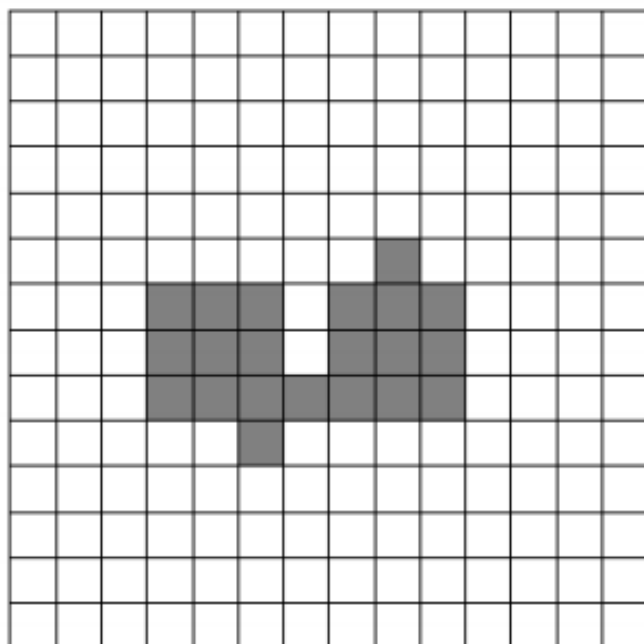
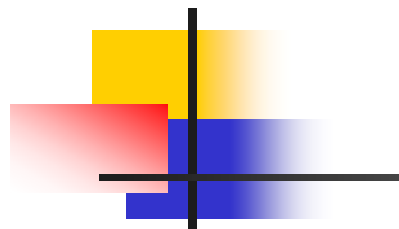
9.2.1 Erosão

$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$

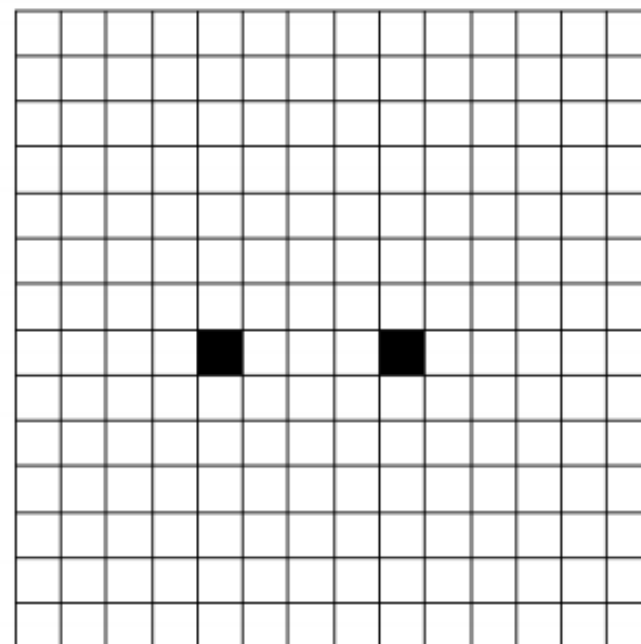
$$A \ominus B = \{z \mid (B)_z \cap A^c = \emptyset\}$$

Conjunto B definido
como ELEMENTO
ESTRUTURANTE

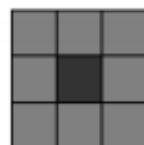




F

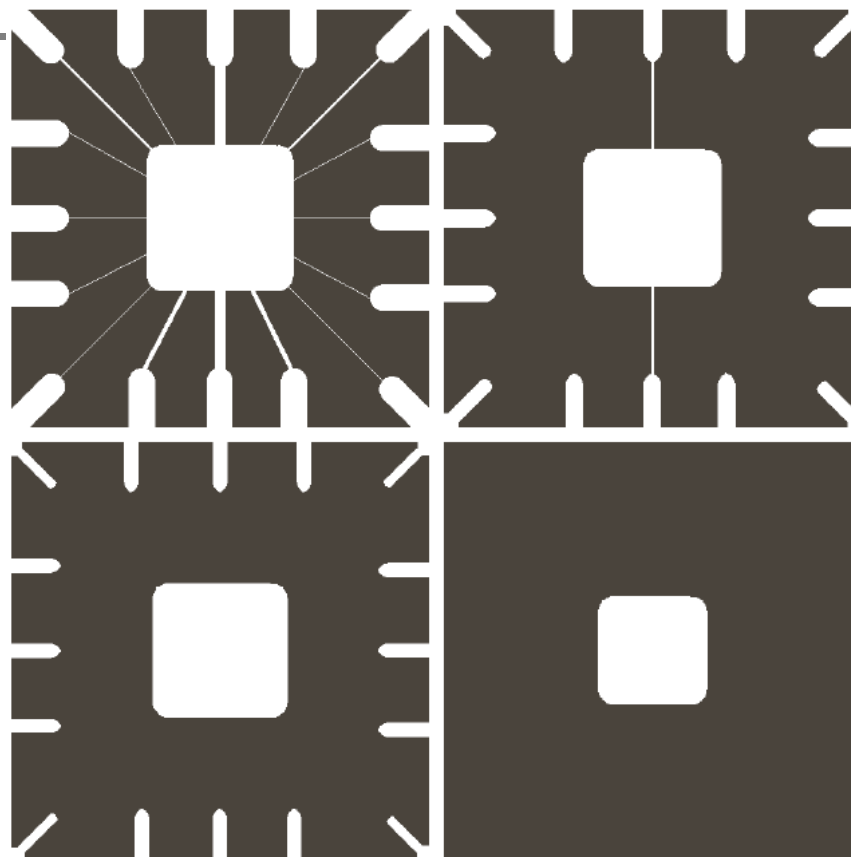
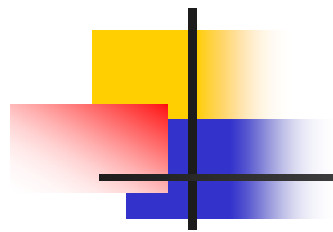


G



H, 3x3, origin at the center

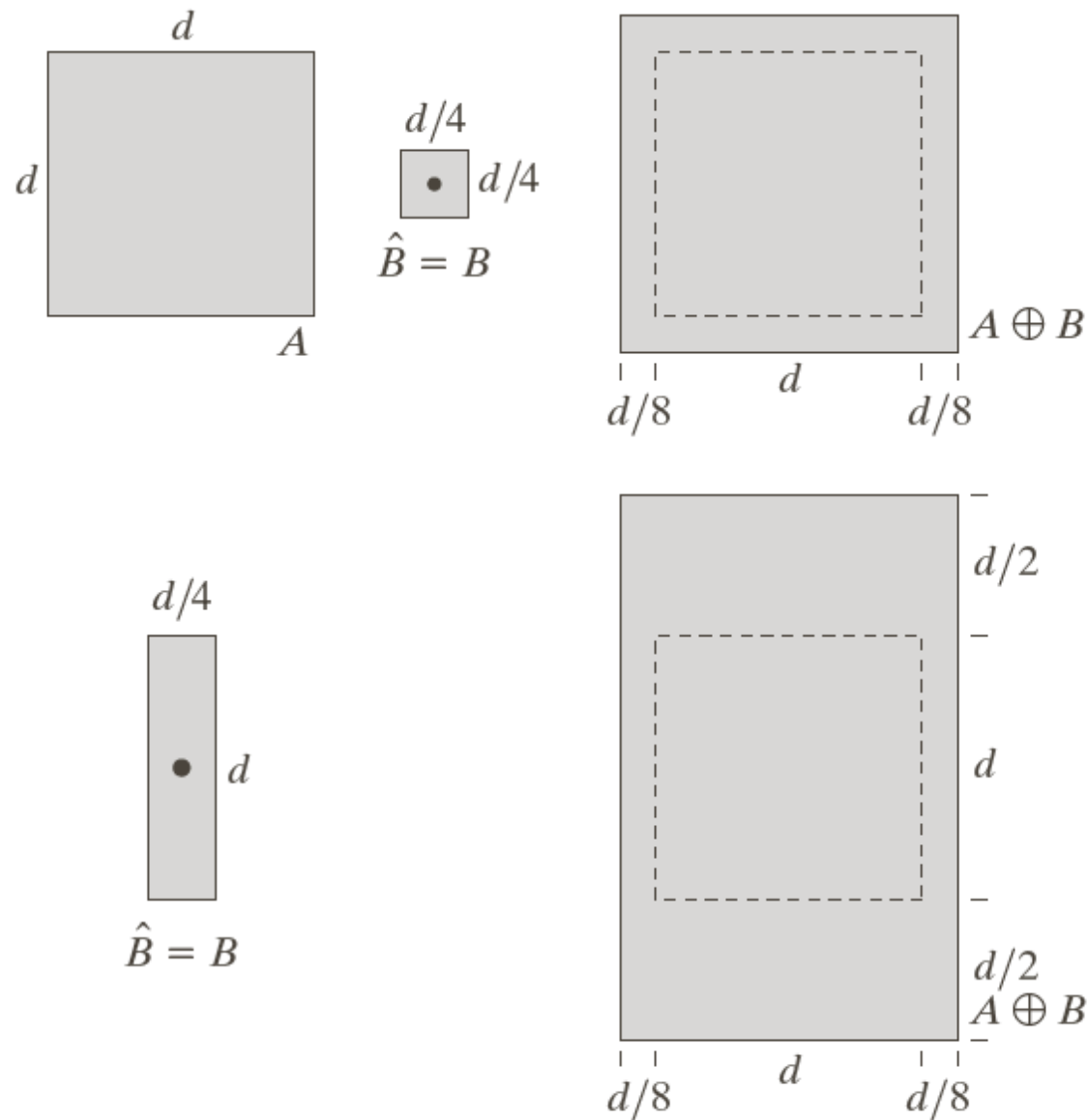
Remoção de componentes da imagem

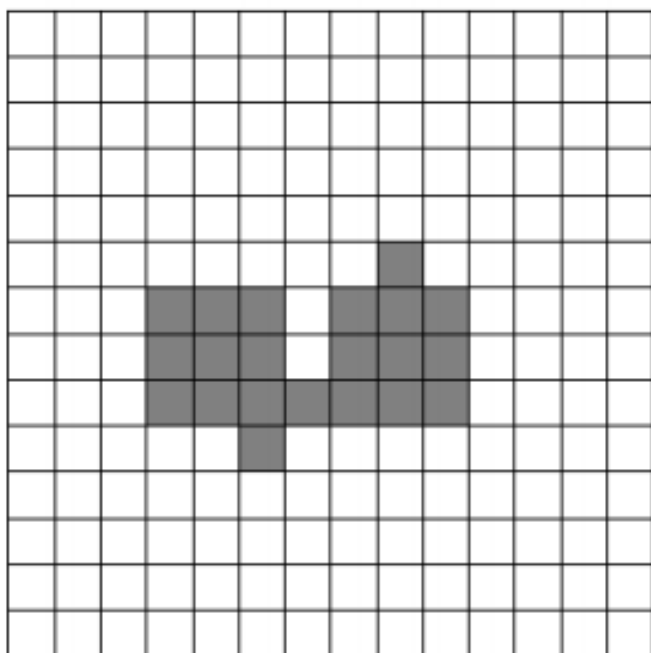
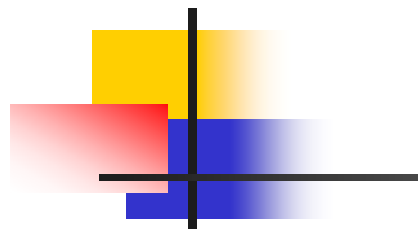


9.2.2 Dilatação

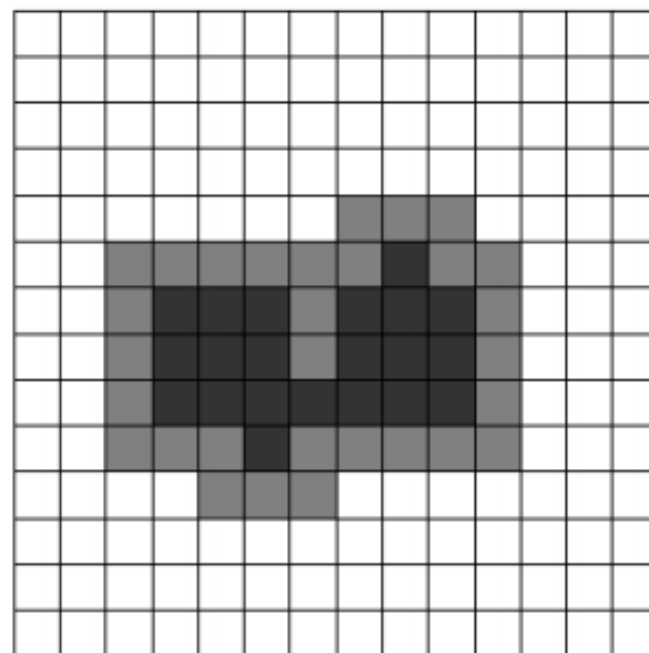
$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \emptyset\}$$

$$A \oplus B = \{z \mid [(\hat{B})_z \cap A] \subseteq A\}$$

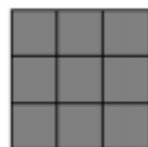




F



G



H, 3x3, origin at the center

Aplicação no preenchimento de espaço (gap filling)

Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.



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0	1	0
1	1	1
0	1	0



9.2.3 Dualidade

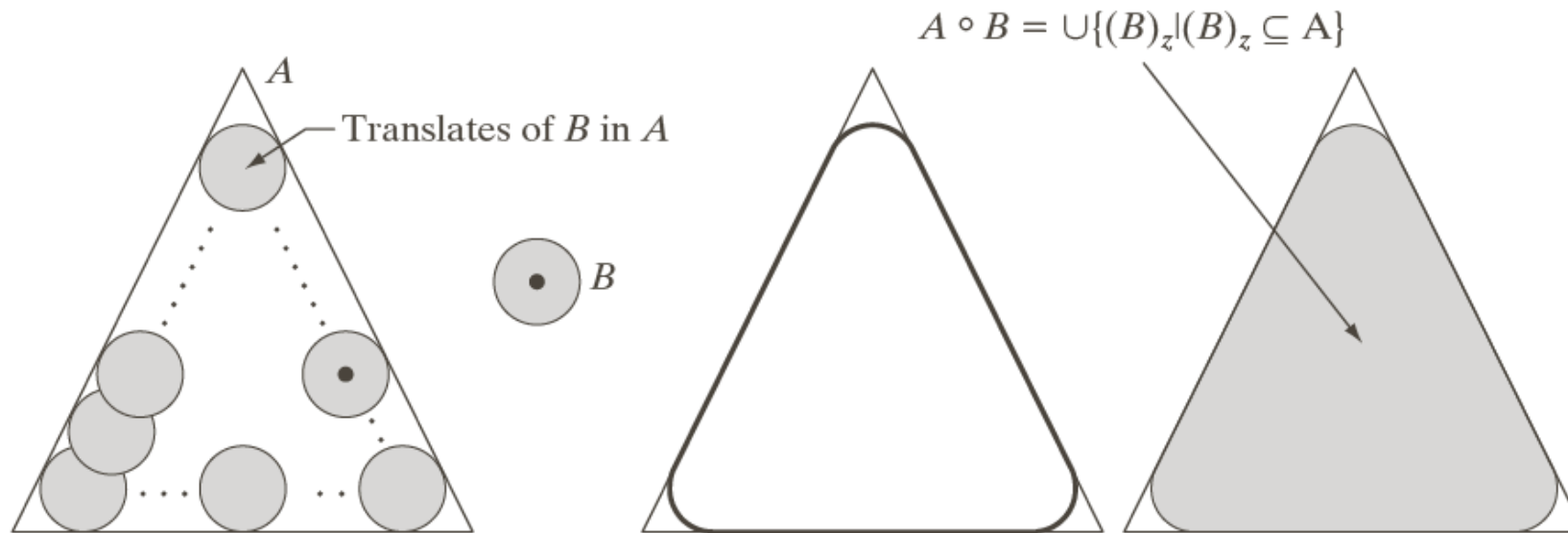
$$(A \ominus B)^c = A^c \oplus \hat{B}$$

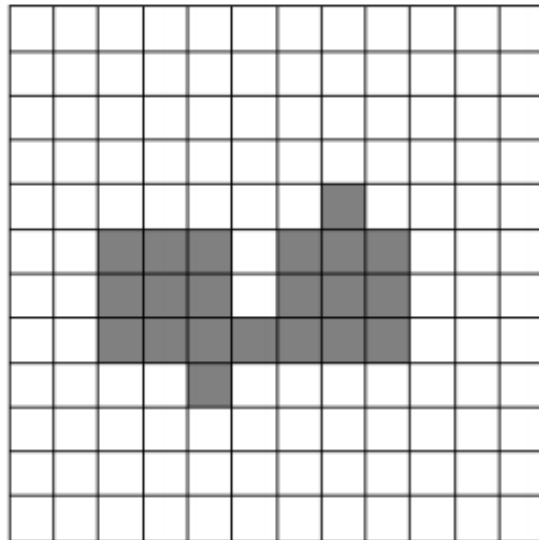
$$(A \oplus B)^c = A^c \ominus \hat{B}$$

9.3 Abertura

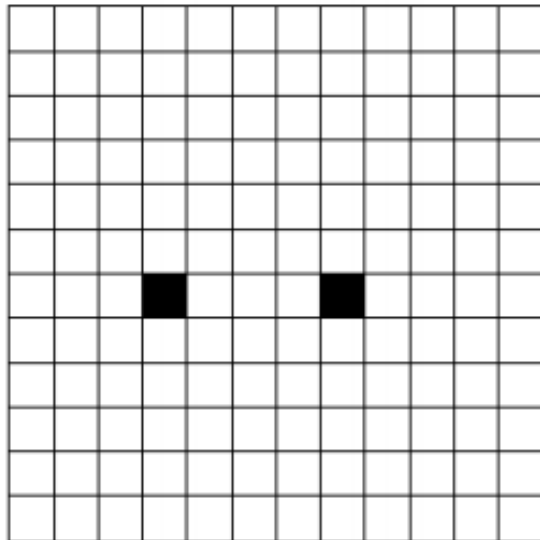
$$A \circ B = (A \ominus B) \oplus B$$

- Suavizar contornos de um objeto
- Rompe os istmos e elimina as saliências finas

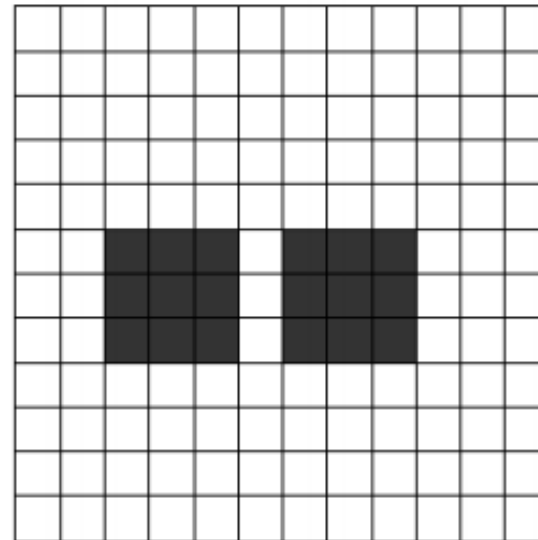




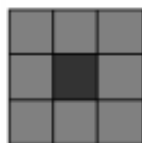
F



$F \ominus H$



$(F \ominus H) \oplus H$

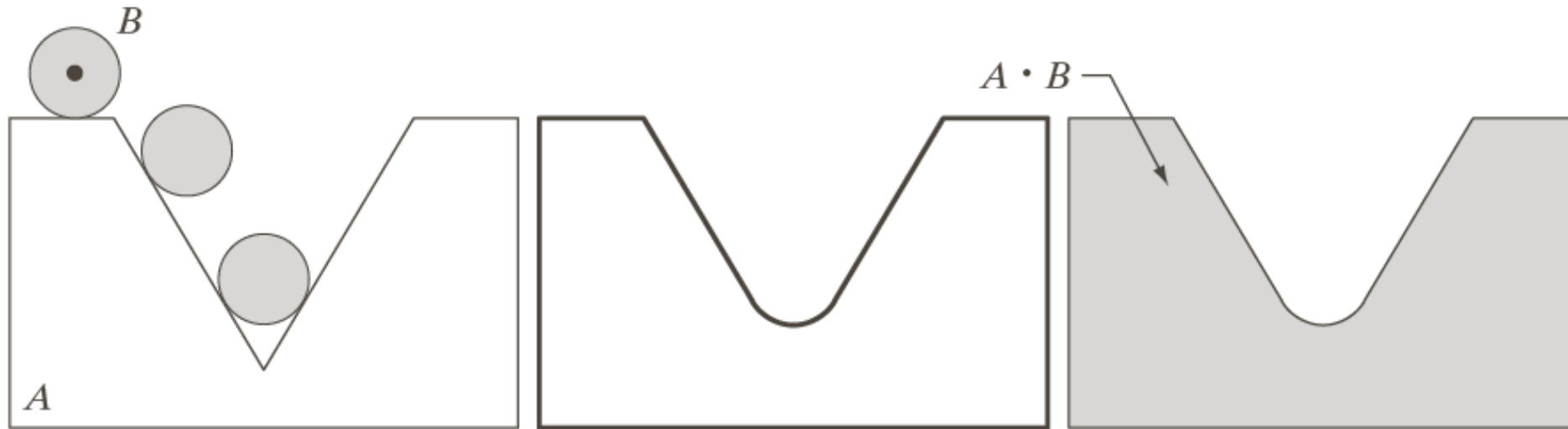


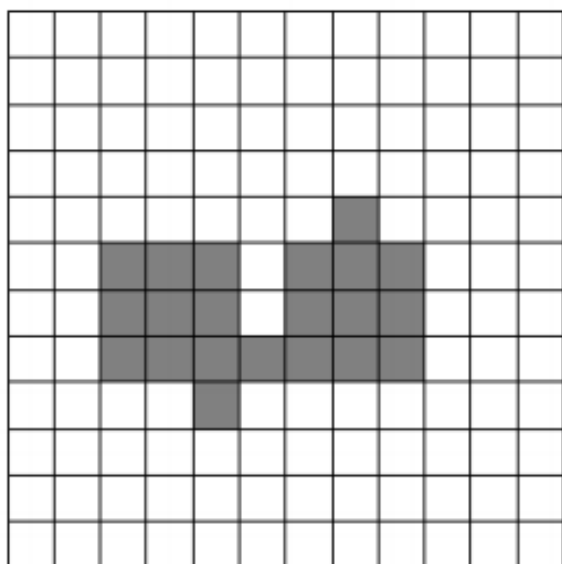
H, 3x3, origin at the center

9.3 Fechamento

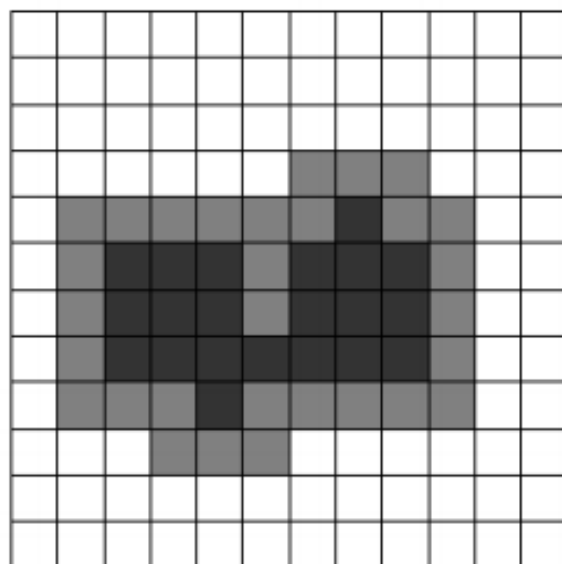
$$A \bullet B = (A \oplus B) \ominus B$$

- Suavizar contornos de um objeto
- Geralmente funde as descontinuidades estreitas alonga os golfos finos
- Elimina pequenos buracos e preenche as lacunas em um contorno

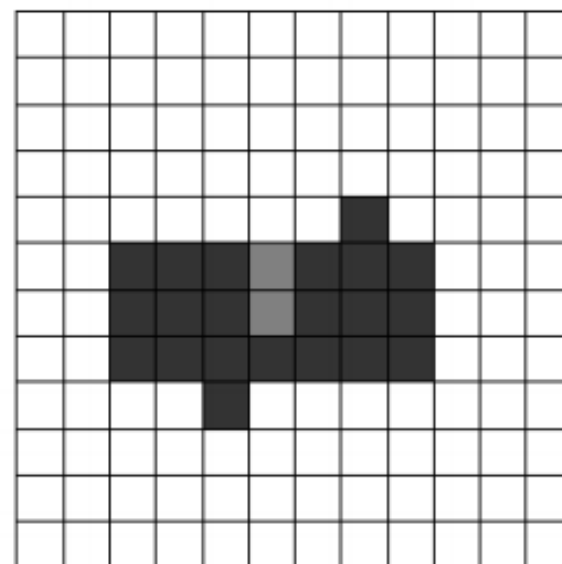




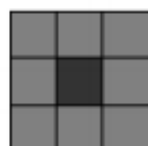
F



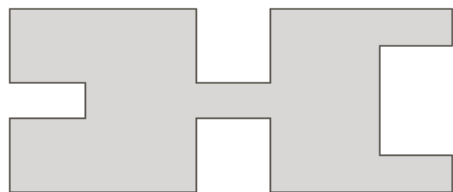
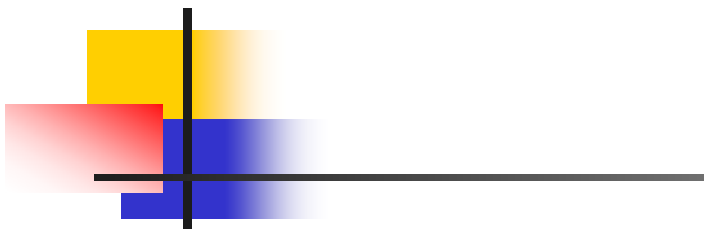
$F \oplus H$



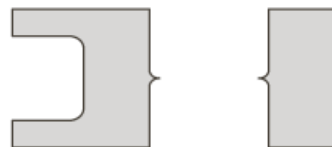
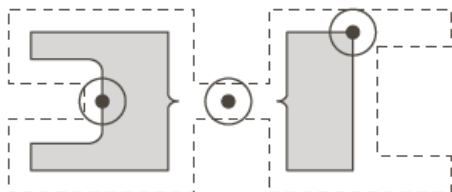
$(F \oplus H) \odot H$



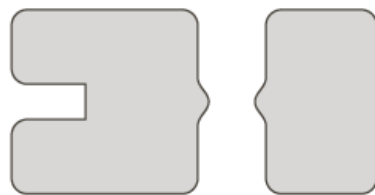
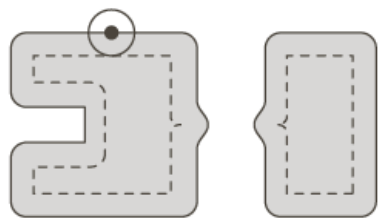
H , 3x3, origin at the center



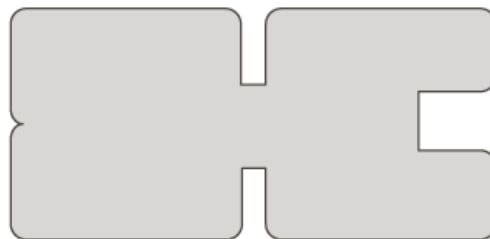
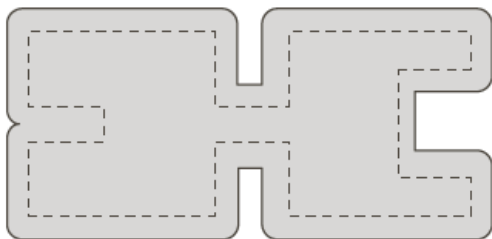
A



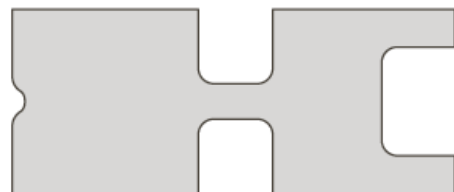
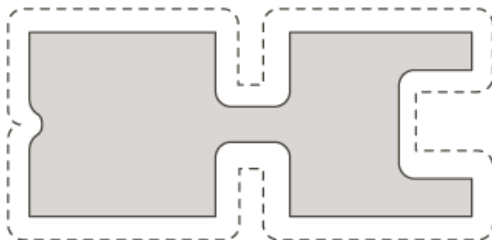
$A \ominus B$



$A \circ B = (A \ominus B) \oplus B$

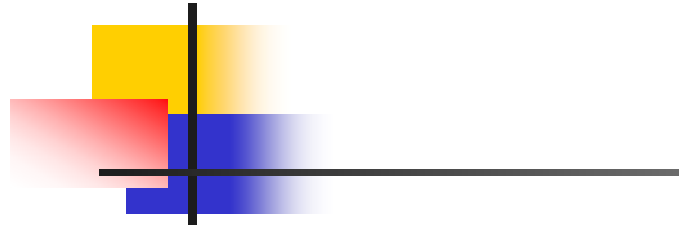


$A \oplus B$



$A \cdot B = (A \oplus B) \ominus B$

Filtragem morfológica

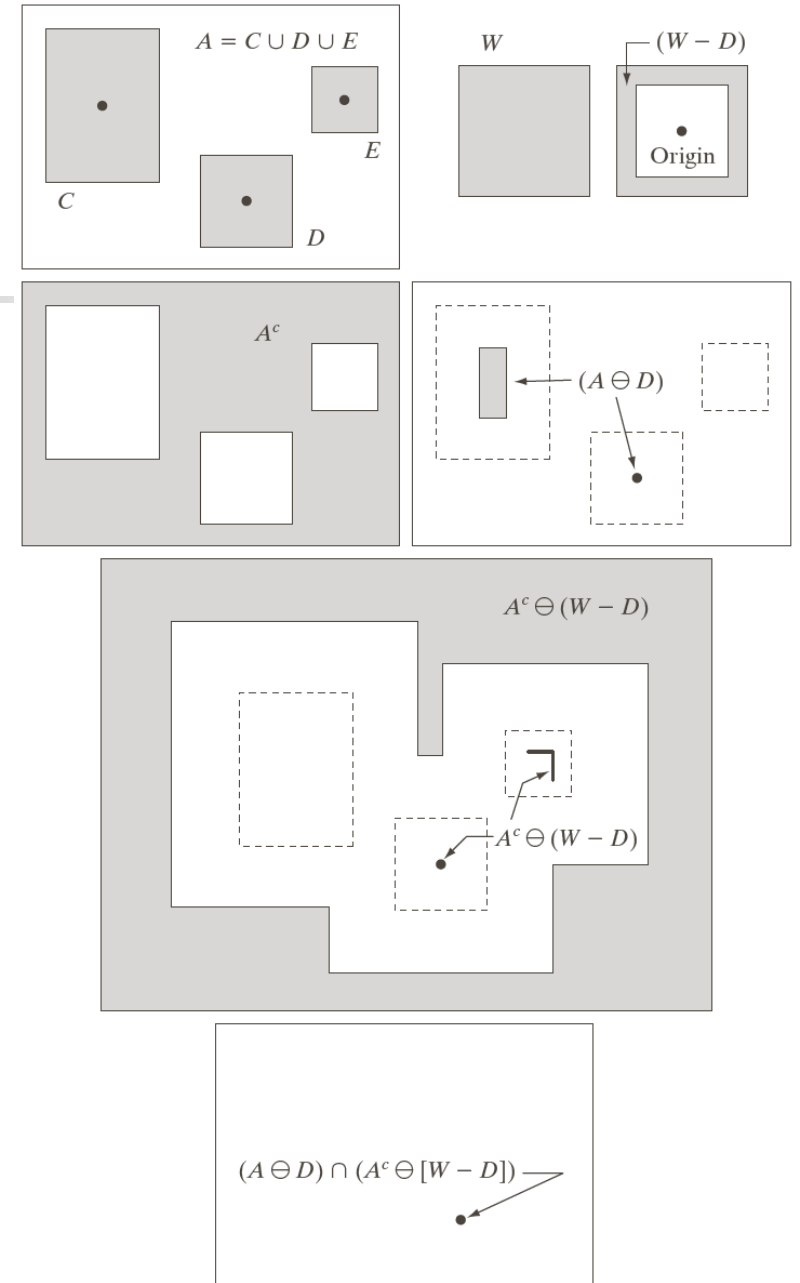


9.4 Transformada hit-or-miss

- Ferramenta básica para a detecção de formas
- Exemplo: Detecção de bordas

$$A \circledast B = (A \ominus D) \cap [A^c \ominus (W - D)]$$

$$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$$





Resumo de operações

Operação	Equação	Comentários (os algarismos romanos referem-se aos elementos estruturantes na Figura 9.33)
Translação	$(B)_z = \{\omega \omega = b + z, \text{ para } b \in B\}$	Translada a origem de B para o ponto z .
Reflexão	$\hat{B} = \{\omega \omega = -b, \text{ para } b \in B\}$	Reflete todos os elementos de B em torno da origem desse conjunto.
Complemento	$A^c = \{\omega \omega \notin A\}$	Conjunto de pontos que não pertencem a A .
Diferença	$A - B = \{\omega \omega \in A, \omega \notin B\}$ $= A \cap B^c$	Conjunto de pontos que pertencem a A mas não a B .
Dilatação	$A \oplus B = \{z (\hat{B}_z) \cap A \neq \emptyset\}$	"Expande" a fronteira de A . (I)
Erosão	$A \ominus B = \{z (B)_z \subseteq A\}$	"Contraí" a fronteira de A . (I)
Abertura	$A \circ B = (A \ominus B) \oplus B$	Suaviza os contornos, quebra os istmos e elimina as pequenas ilhas e os picos agudos. (I)
Fechamento	$A \bullet B = (A \oplus B) \ominus B$	Suaviza os contornos, funde pequenas quebras, alonga os golfos finos e elimina pequenos buracos. (I)

Resumo de operações

Transformada <i>hit-or-miss</i>	$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$ $= (A \ominus B_1) - (A \oplus B_2)$	Conjunto de pontos (coordenadas) em que, simultaneamente, B_1 encontra um acerto (<i>hit</i>) em A e B_2 encontra um acerto em A^c
Extração de fronteiras	$\beta(A) = A - (A \ominus B)$	Conjunto de pontos na fronteira do conjunto A . (I)
Preenchimento de buracos	$X_k = (X_{k-1} \oplus B) \cap A^c;$ $k = 1, 2, 3, \dots$	Preenche os buracos em A ; X_0 = arranjo matricial de 0s com um 1 em cada buraco. (II)
Componentes conexos	$X_k = (X_{k-1} \oplus B) \cap A;$ $k = 1, 2, 3, \dots$	Localiza os componentes conexos em A ; X_0 = arranjo matricial de 0s com um 1 em cada componente conexo. (I)
Fecho convexo	$X_k^i = (X_{k-1}^i \circledast B^i) \cup A;$ $i = 1, 2, 3, 4;$ $k = 1, 2, 3, \dots;$ $X_0^i = A; \text{ e}$ $D^i = X_{\text{conv}}^i$	Localiza o fecho convexo $C(A)$ do conjunto A , no qual "conv" indica convergência no sentido de que $X_k^i = X_{k-1}^i$ (III)
Afinamento	$A \otimes B = A - (A \circledast B)$ $= A \cap (A \circledast B)^c$ $A \otimes \{B\} = ((\dots((A \otimes B^1)$ $\otimes B^2) \dots) \otimes B^n)$ $\{B\} = \{B^1, B^2, B^3, \dots, B^n\}$	Afina o conjunto A . As duas primeiras equações oferecem a definição básica de afinamento. As últimas equações denotam o afinamento por uma sequência de elementos estruturantes. Este método é normalmente utilizado na prática. (IV)

Resumo de operações

Transformada <i>hit-or-miss</i>	$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$ $= (A \ominus B_1) - (A \oplus B_2)$	Conjunto de pontos (coordenadas) em que, simultaneamente, B_1 encontra um acerto (<i>hit</i>) em A e B_2 encontra um acerto em A^c
Extração de fronteiras	$\beta(A) = A - (A \ominus B)$	Conjunto de pontos na fronteira do conjunto A . (I)
Preenchimento de buracos	$X_k = (X_{k-1} \oplus B) \cap A^c;$ $k = 1, 2, 3, \dots$	Preenche os buracos em A ; X_0 = arranjo matricial de 0s com um 1 em cada buraco. (II)
Componentes conexos	$X_k = (X_{k-1} \oplus B) \cap A;$ $k = 1, 2, 3, \dots$	Localiza os componentes conexos em A ; X_0 = arranjo matricial de 0s com um 1 em cada componente conexo. (I)
Fecho convexo	$X_k^i = (X_{k-1}^i \circledast B^i) \cup A;$ $i = 1, 2, 3, 4;$ $k = 1, 2, 3, \dots;$ $X_0^i = A; \text{ e}$ $D^i = X_{\text{conv}}^i$	Localiza o fecho convexo $C(A)$ do conjunto A , no qual "conv" indica convergência no sentido de que $X_k^i = X_{k-1}^i$ (III)
Afinamento	$A \otimes B = A - (A \circledast B)$ $= A \cap (A \circledast B)^c$ $A \otimes \{B\} = ((\dots((A \otimes B^1)$ $\otimes B^2)\dots) \otimes B^n)$ $\{B\} = \{B^1, B^2, B^3, \dots, B^n\}$	Afina o conjunto A . As duas primeiras equações oferecem a definição básica de afinamento. As últimas equações denotam o afinamento por uma sequência de elementos estruturantes. Este método é normalmente utilizado na prática. (IV)

