

Aula 10 – Segmentação de imagens III

Regiões

Prof. João Fernando Mari

joaofmari.github.io

joaof.mari@ufv.br

- Crescimento de regiões
- Divisão e fusão de regiões

CRESCIMENTO DE REGIÕES

Crescimento de regiões

- $f(x, y)$ é a imagem de entrada;
- $S(x, y)$ é uma imagem contendo sementes:
 - S é uma imagem binária com o mesmo tamanho da imagem f .
 - Os pixels com valor **1** indicam as sementes e os **0**s as demais localizações;
- Q denota **alguma propriedade** a ser aplicada em cada posição (x, y) .

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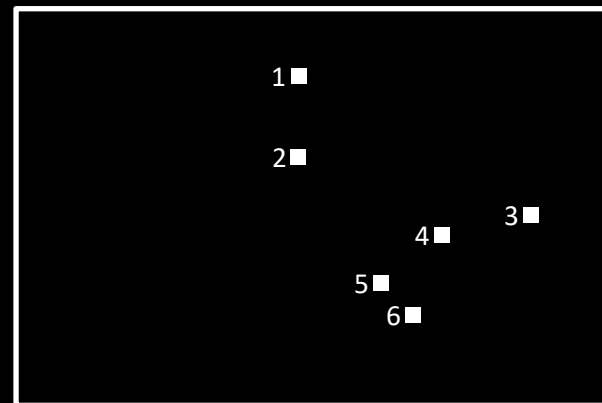
$f(x, y)$



Marcadores para as sementes



$S(x, y)$



Crescimento de regiões

- Algoritmo básico de crescimento da regiões (baseado em conectividade-8):
 - Reduzir cada componente conectado em $S(x, y)$ a um único pixel (erosão morfológica).
 - Rotular todos os pixels, $r = [1, 2, 3, \dots N]$.
 - Para cada semente r , gerar uma imagem f_r em que:
 - $f_r(x, y) = r$, se o pixel da imagem de entrada satisfaz Q ;
 - $f_r(x, y) = 0$, caso contrário.
 - A imagem de saída g é formada anexando a cada semente em S todos os pixels rotulados com o número r em f_r que estão 8-conectados a essa semente.
 - Em caso de conflito atribuir ao menor rótulo. “O primeiro leva tudo”.

Crescimento de regiões

- (A) Imagem original $f(x, y)$ com tamanho 5 x 5, profundidade de 3 bits ($L = 8$) e duas sementes.

(A)

7	0	5	6	5
5	1	5	7	7
0	3	6	5	6
2	1	7	7	6
0	1	5	6	1

$f(x, y)$

Crescimento de regiões

- (B) Imagem com as sementes $S(x, y)$. As sementes já foram reduzidas a um único pixel e rotuladas.

(A)

7	0	5	6	5
5	1	5	7	7
0	3	6	5	6
2	1	7	7	6
0	1	5	6	1

$f(x, y)$

(B)

0	0	0	0	0
0	0	0	2	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0

$S(x, y)$

Crescimento de regiões

- (C) Imagem com as diferenças absolutas entre o pixel sob a semente com rótulo 1 e os demais pixels.
 - Propriedade Q: diferença absoluta entre os pixels (T).

(A)

7	0	5	6	5
5	1	5	7	7
0	3	6	5	6
2	1	7	7	6
0	1	5	6	1

$f(x, y)$

(C)

6	1	4	5	4
4	0	4	6	6
1	2	5	4	5
1	0	6	6	5
1	0	4	5	0

$T_1 = |f(x, y) - 1|$

(B)

0	0	0	0	0
0	0	0	2	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0

$S(x, y)$

Crescimento de regiões

- (D) Imagem com as diferenças absolutas entre o pixel sob a semente com rótulo **2** e os demais pixels.
 - Propriedade Q: diferença absoluta entre os pixels (T).

(A)

7	0	5	6	5
5	1	5	7	7
0	3	6	5	6
2	1	7	7	6
0	1	5	6	1

$f(x, y)$

(C)

6	1	4	5	4
4	0	4	6	6
1	2	5	4	5
1	0	6	6	5
1	0	4	5	0

$T_1 = |f(x, y) - 1|$

(B)

0	0	0	0	0
0	0	0	2	0
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0

$S(x, y)$

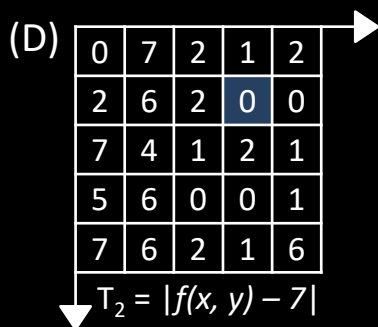
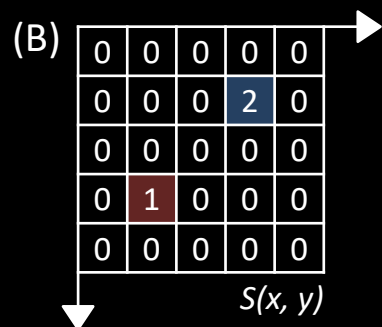
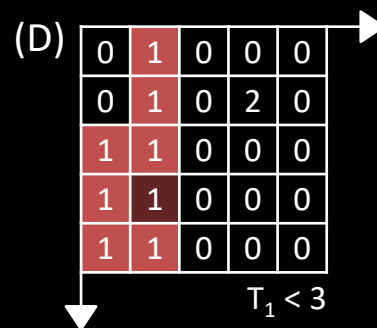
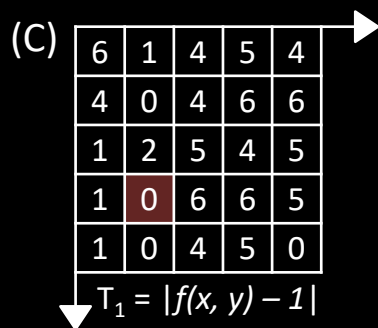
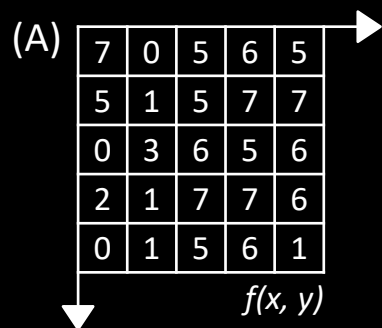
(D)

0	7	2	1	2
2	6	2	0	0
7	4	1	2	1
5	6	0	0	1
7	6	2	1	6

$T_2 = |f(x, y) - 7|$

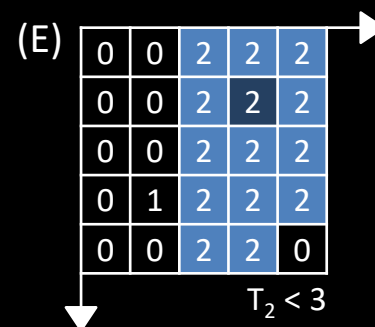
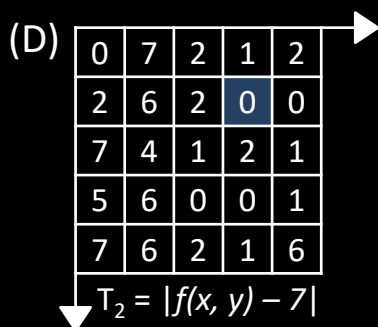
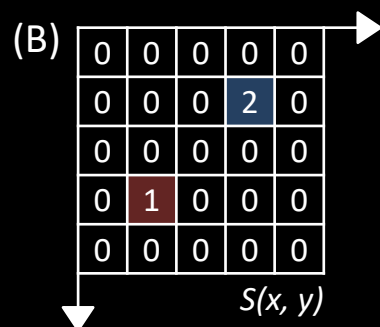
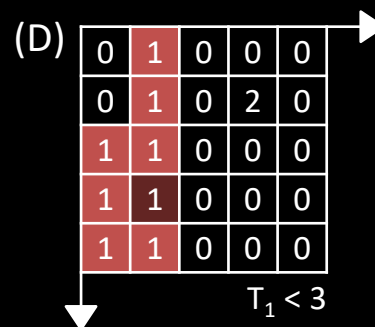
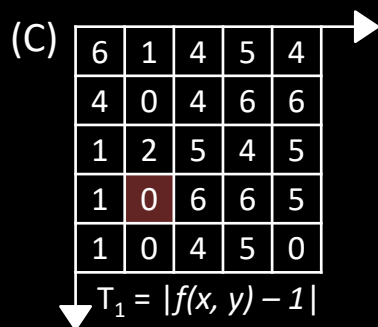
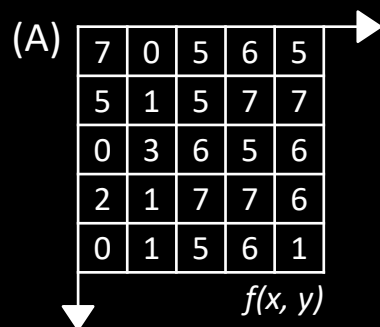
Crescimento de regiões

- (E) Segmentação da imagem f considerando $Q = T < 3$.
 - Pixels em T_1 que satisfazem Q e possuem um caminho 8-conectado à semente.



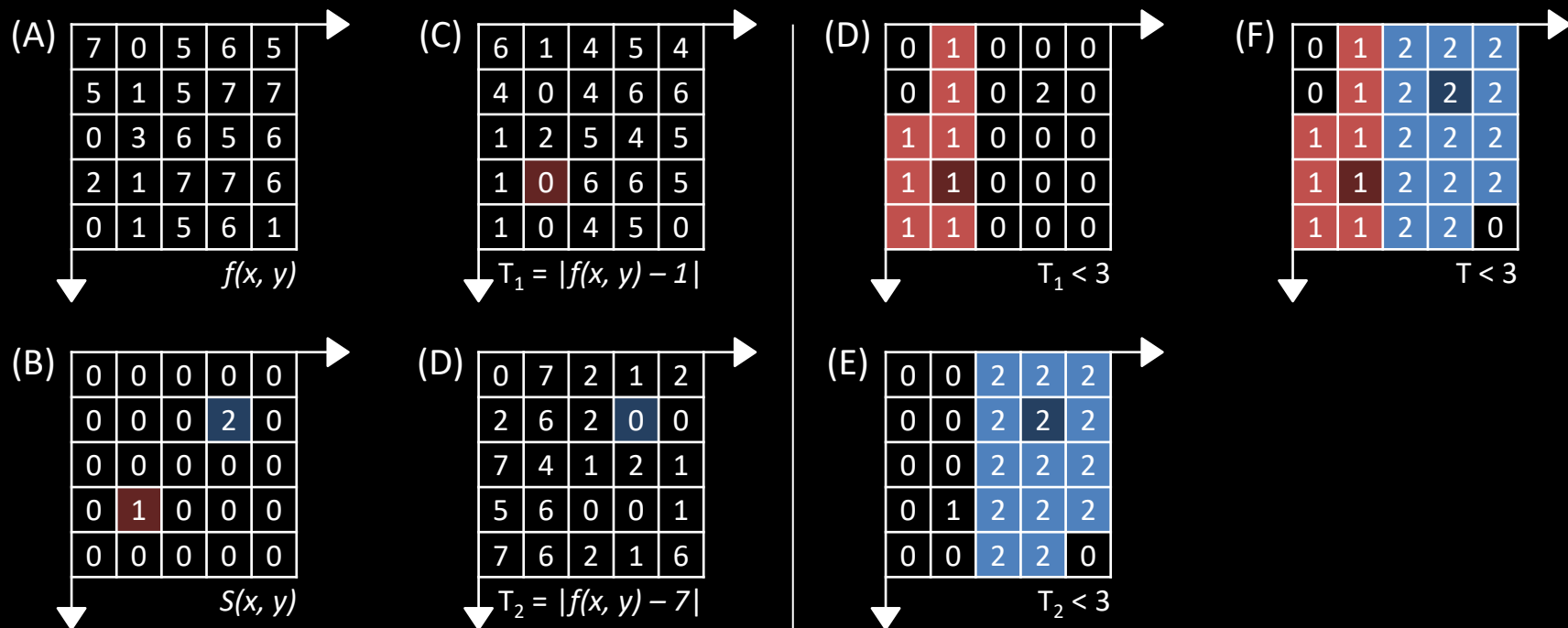
Crescimento de regiões

- (E) Segmentação da imagem f considerando $Q = T < 3$.
 - Pixels em T_2 que satisfazem Q e possuem um caminho 8-conectado à semente.



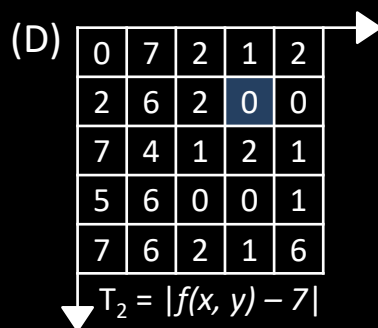
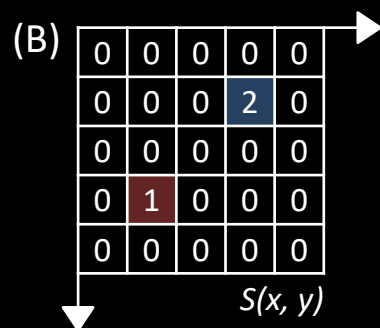
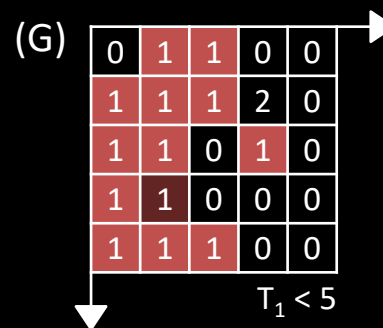
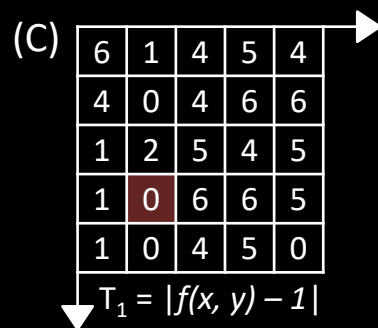
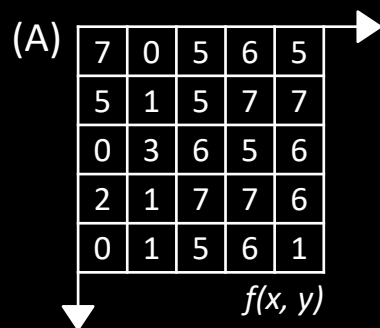
Crescimento de regiões

- (F) Segmentação da imagem f considerando $Q = T < 3$.



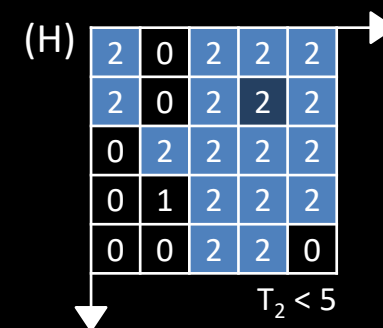
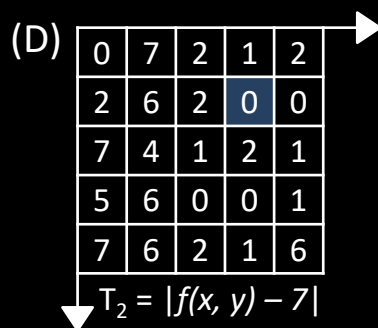
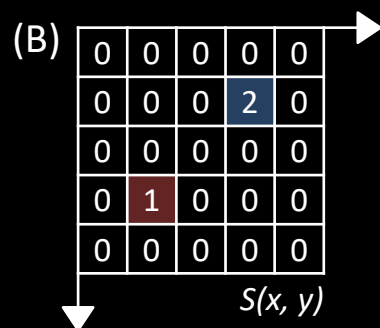
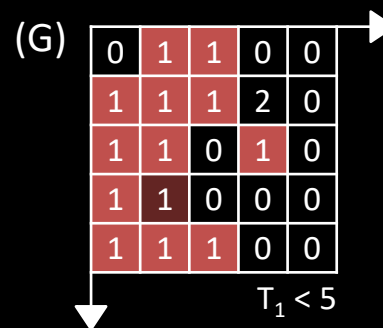
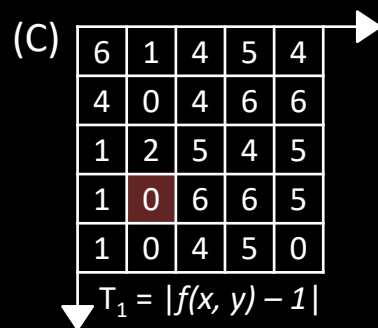
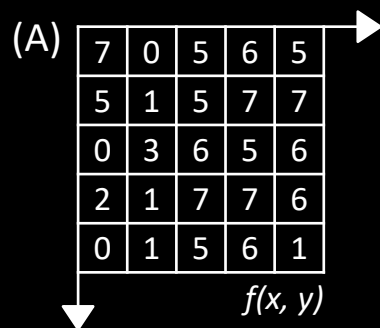
Crescimento de regiões

- (G) Segmentação da imagem f considerando $Q = T < 5$.
 - Pixels em T_1 que satisfazem Q e possuem um caminho 8-conectado à semente.



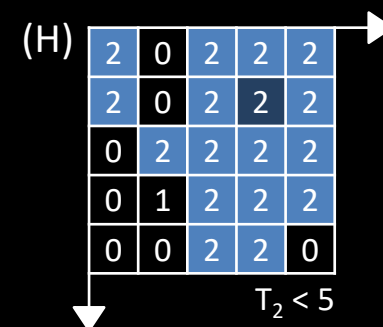
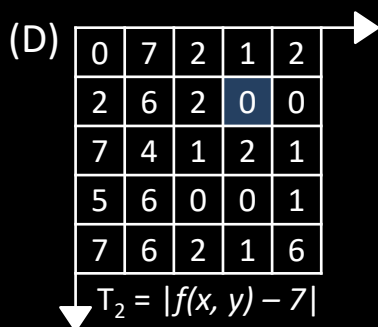
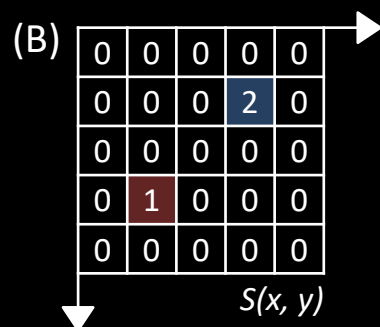
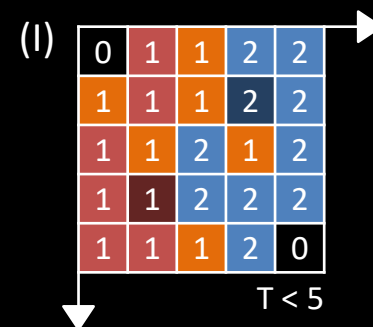
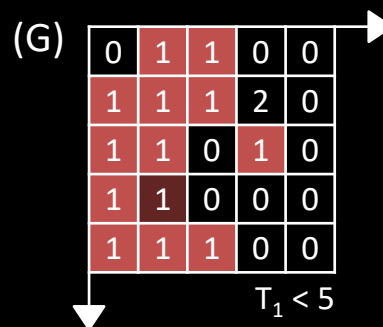
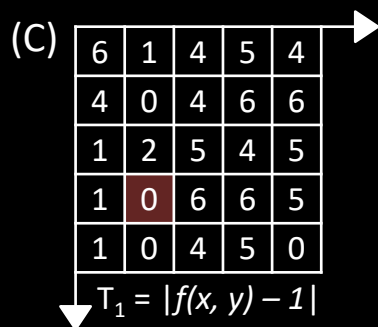
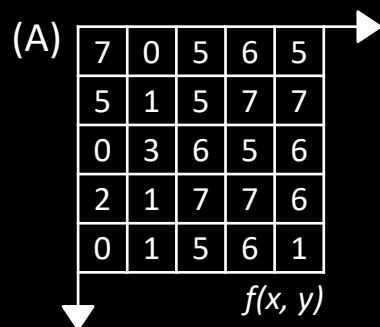
Crescimento de regiões

- (H) Segmentação da imagem f considerando $Q = T < 5$.
 - Pixels em T_2 que satisfazem Q e possuem um caminho 8-conectado à semente.



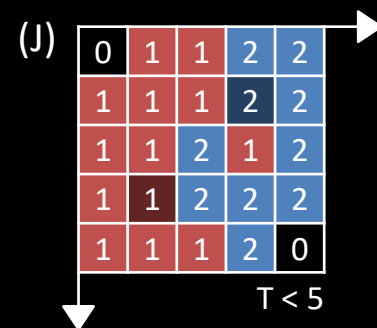
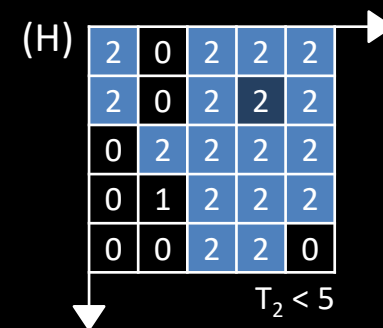
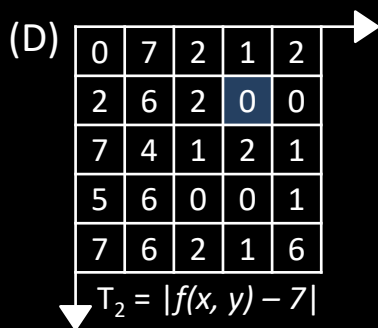
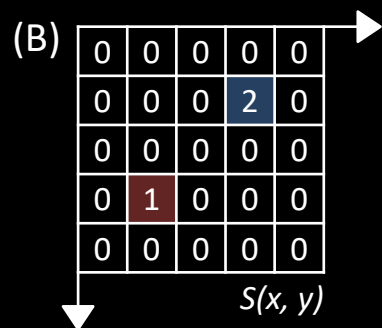
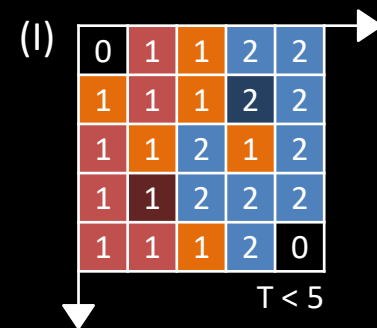
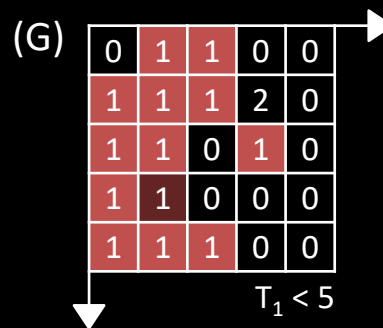
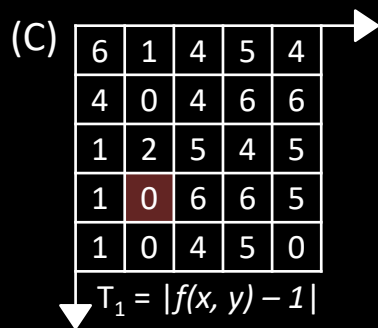
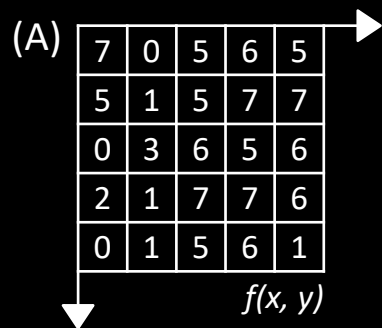
Crescimento de regiões

- (I) Segmentação da imagem f considerando $Q = T < 5$.
 - Em caso de conflito, o pixel é atribuído a região com o menor rótulo de forma arbitrária.



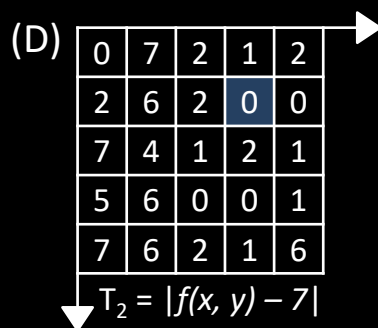
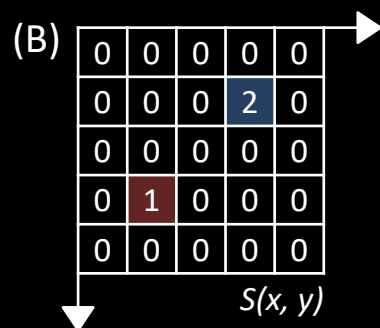
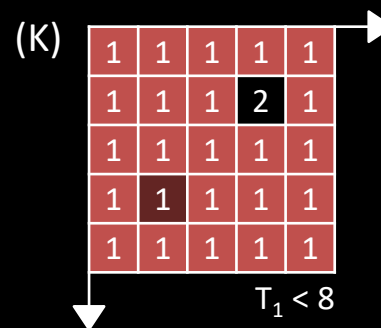
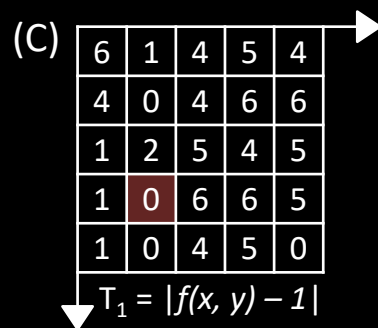
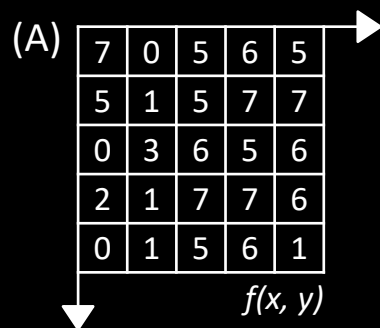
Crescimento de regiões

- (J) Segmentação da imagem f considerando $Q = T < 5$.



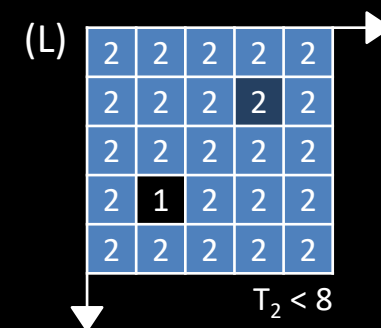
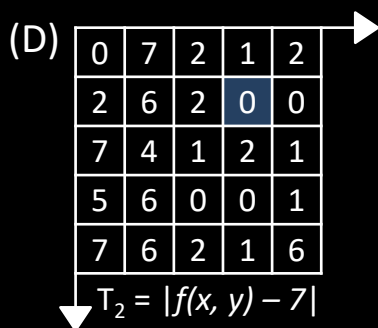
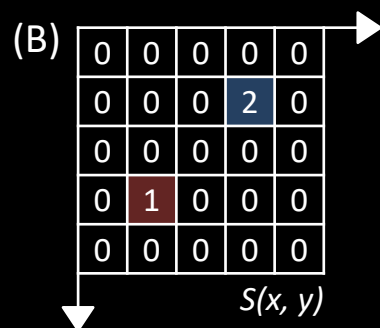
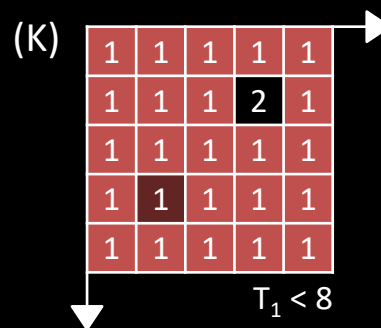
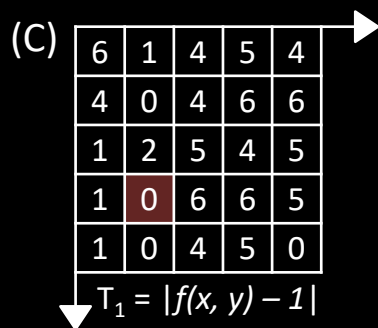
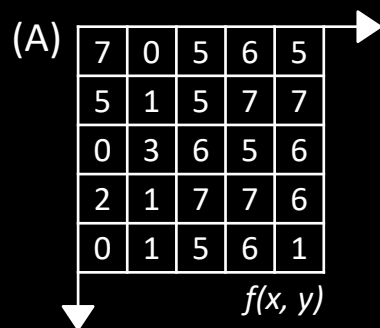
Crescimento de regiões

- (K) Segmentação da imagem f considerando $Q = T < 8$.
 - Pixels em T_1 que satisfazem Q e possuem um caminho 8-conectado à semente.



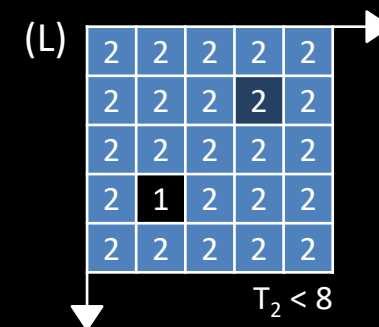
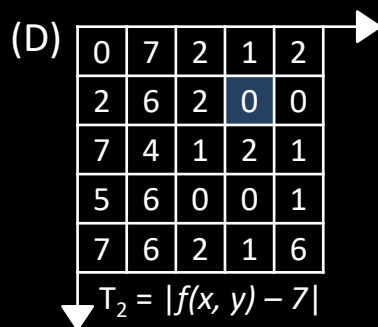
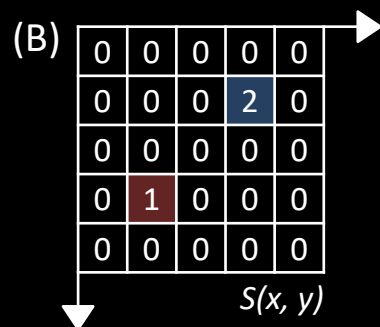
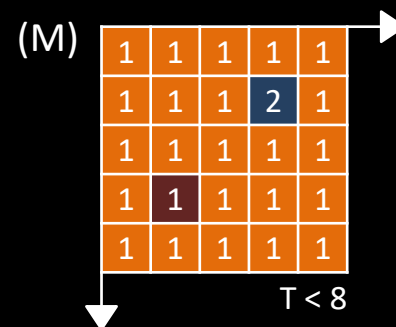
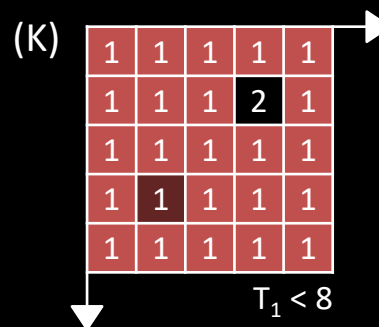
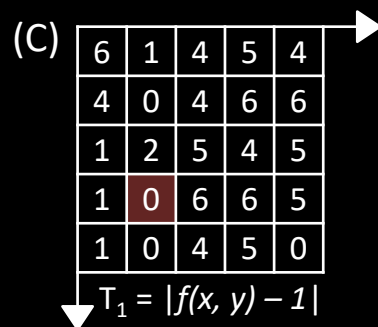
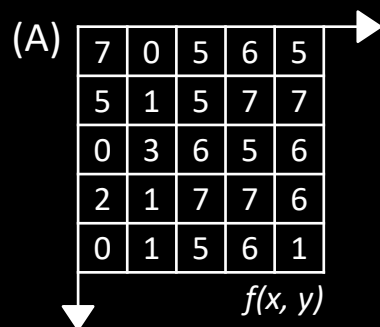
Crescimento de regiões

- (L) Segmentação da imagem f considerando $Q = T < 8$.
 - Pixels em T_2 que satisfazem Q e possuem um caminho 8-conectado à semente.



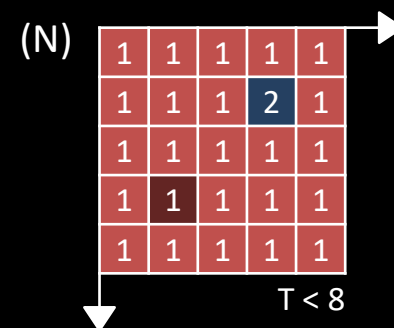
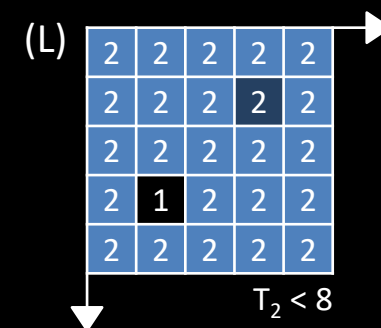
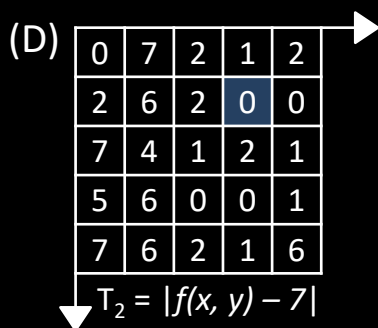
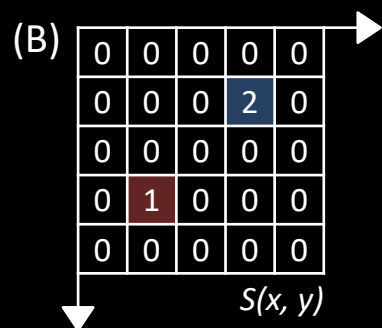
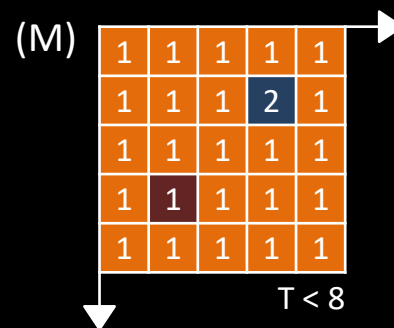
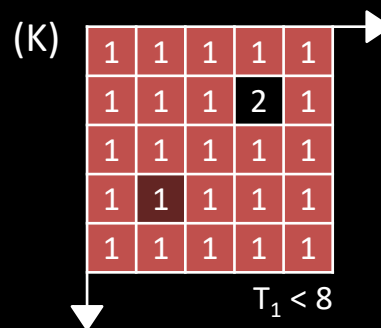
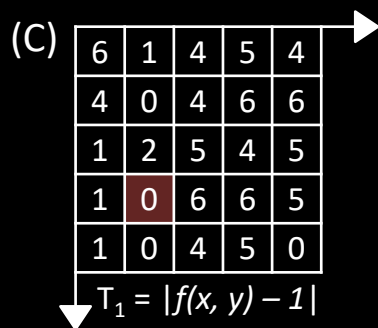
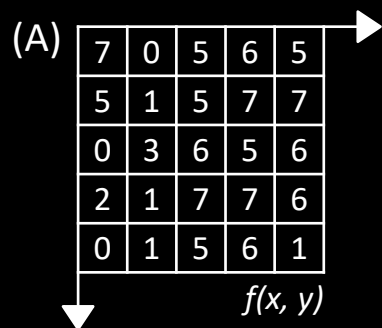
Crescimento de regiões

- (M) Segmentação da imagem f considerando $Q = T < 8$.
 - Em caso de conflito, o pixel é atribuído a região com o menor rótulo de forma arbitrária.



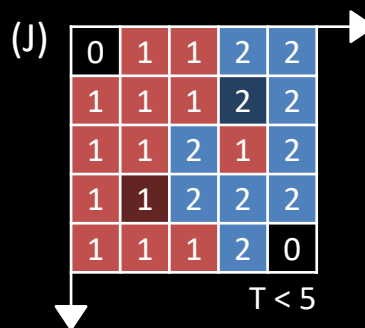
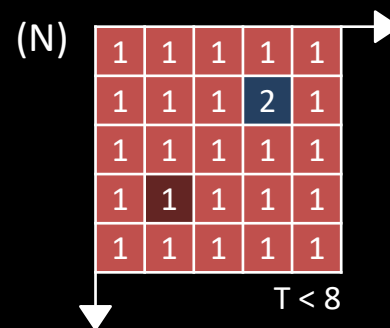
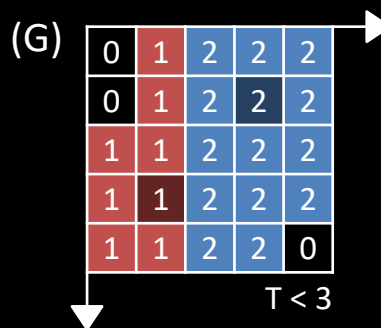
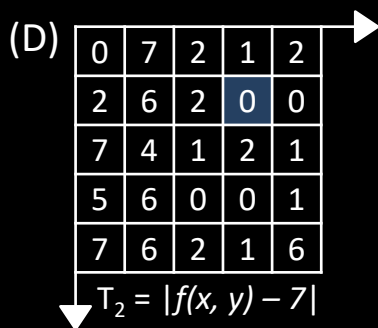
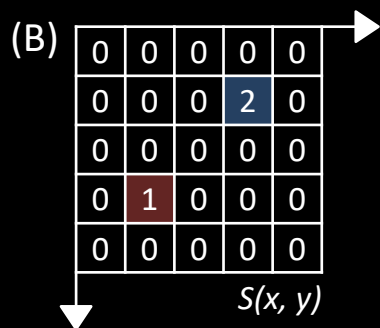
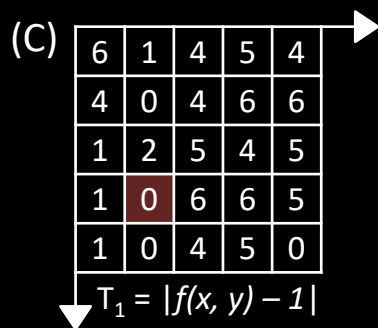
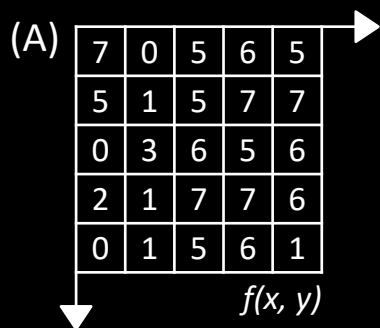
Crescimento de regiões

- (N) Segmentação da imagem f considerando $Q = T < 8$.
 - Com $T < 8$, todos os pixels atribuídos à semente 1.



Crescimento de regiões

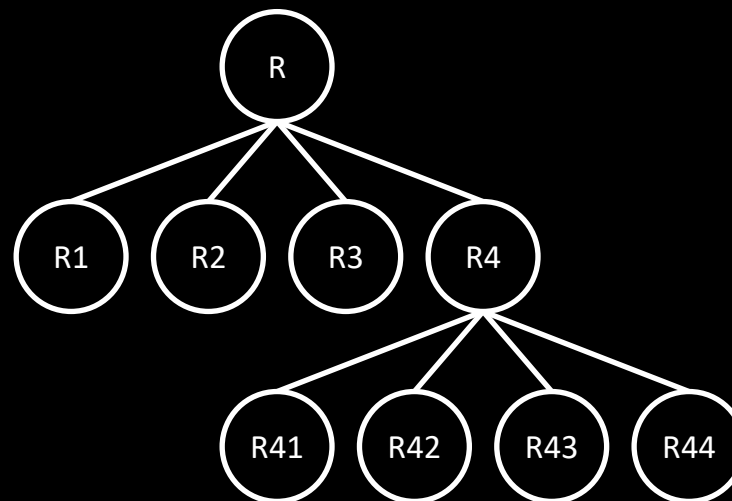
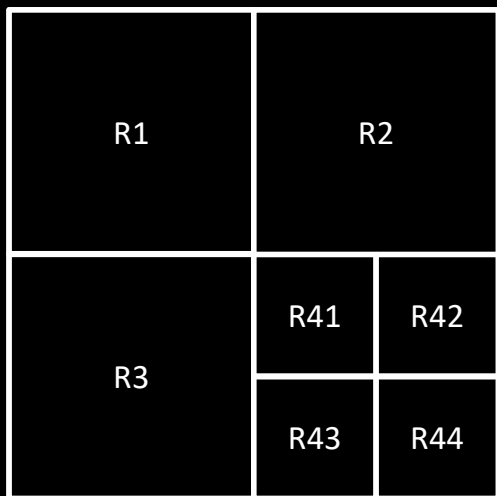
- Segmentações da imagem f considerando (G) $Q = T < 3$; (J) $Q = T < 5$; (N) $Q = T < 8$.



DIVISÃO E FUSÃO DE REGIÕES

Divisão e fusão de regiões

- Algoritmo de divisão e fusão de regiões.
 - Dividir em quatro quadrantes qualquer região R_i em que $Q(R_i) = \text{Falso}$.
 - Quando não for possível dividir um região, fundir as regiões adjacentes R_j e R_k em que $Q(R_j \cup R_k) = \text{Verdade}$.
 - Parar quando a fusão não for mais possível.



Divisão e fusão de regiões

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

Divisão e fusão de regiões

$$\mu=1.88$$

$$\sigma=2.24$$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

$\mu=2.81$
 $\sigma=2.48$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

$\mu=1.44$
 $\sigma=2.09$

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

$\mu=1.38$
 $\sigma=0.99$

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

$\mu=1.88$
 $\sigma=2.69$

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

$\mu=2.81$
 $\sigma=2.48$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

$\mu=1.44$
 $\sigma=2.09$

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

$\mu=1.38$
 $\sigma=0.99$

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

$\mu=1.88$
 $\sigma=2.69$

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

$\mu=2.81$
 $\sigma=2.48$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

$\mu=1.44$
 $\sigma=2.09$

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

$\mu=1.38$
 $\sigma=0.99$

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

$\mu=1.88$
 $\sigma=2.69$

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

0	0
0	5

0	0
5	5

0	5
0	5

5	5
5	5

0	0
0	0

6	4
3	6

0	0
0	0

2	0
4	0

0	1
0	0

2	1
0	0

7	7
0	0

1	7
0	2

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

$\mu=2.81$
 $\sigma=2.48$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

$\mu=1.44$
 $\sigma=2.09$

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

$\mu=1.38$
 $\sigma=0.99$

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

$\mu=1.88$
 $\sigma=2.69$

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

$\mu=1.25$
 $\sigma=2.17$

0	0
0	5

$\mu=2.50$
 $\sigma=2.50$

0	5
0	5

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

$\mu=0.25$
 $\sigma=0.43$

0	1
0	0

$\mu=2.50$
 $\sigma=2.50$

0	0
5	5

$\mu=5.00$
 $\sigma=0.00$

5	5
5	5

$\mu=4.75$
 $\sigma=1.30$

6	4
3	6

$\mu=0.75$
 $\sigma=0.83$

2	1
0	0

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

$\mu=3.50$
 $\sigma=3.50$

7	7
0	0

$\mu=1.50$
 $\sigma=1.66$

2	0
4	0

$\mu=2.50$
 $\sigma=2.69$

1	7
0	2

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

$\mu=2.81$
 $\sigma=2.48$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

$\mu=1.44$
 $\sigma=2.09$

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

$\mu=1.38$
 $\sigma=0.99$

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

$\mu=1.88$
 $\sigma=2.69$

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

0	0
0	5

0	5
0	5

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

$\mu=0.25$
 $\sigma=0.43$

0	1
0	0

0	0
5	5

$\mu=5.00$
 $\sigma=0.00$

5	5
5	5

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

2	0
4	0

6	4
3	6

$\mu=0.75$
 $\sigma=0.83$

2	1
0	0

7	7
0	0

1	7
0	2

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

$\mu=2.81$
 $\sigma=2.48$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

$\mu=1.44$
 $\sigma=2.09$

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

$\mu=1.38$
 $\sigma=0.99$

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

$\mu=1.88$
 $\sigma=2.69$

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

0	0
0	5

0	5
0	5

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

$\mu=0.25$
 $\sigma=0.43$

0	1
0	0

0	0
5	5

$\mu=5.00$
 $\sigma=0.00$

5	5
5	5

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

2	0
4	0

6	4
3	6

$\mu=0.75$
 $\sigma=0.83$

2	1
0	0

7	7
0	0

1	7
0	2

Divisão e fusão de regiões

$\mu=1.88$
 $\sigma=2.24$

0	0	0	0	0	0	0	0
0	5	5	5	1	1	2	2
0	5	5	5	1	1	2	2
0	5	5	5	3	3	2	2
0	0	6	4	0	0	2	0
0	0	3	6	0	0	4	0
0	1	2	1	7	7	1	7
0	0	0	0	0	0	0	2

Q: $\mu > 2.5$ e $\sigma > 1.0$

$\mu=2.81$
 $\sigma=2.48$

0	0	0	0
0	5	5	5
0	5	5	5
0	5	5	5

$\mu=1.44$
 $\sigma=2.09$

0	0	6	4
0	0	3	6
0	1	2	1
0	0	0	0

$\mu=1.38$
 $\sigma=0.99$

0	0	0	0
1	1	2	2
1	1	2	2
3	3	2	2

$\mu=1.88$
 $\sigma=2.69$

0	0	2	0
0	0	4	0
7	7	1	7
0	0	0	2

0	0
0	5

0	5
0	5

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

$\mu=0.25$
 $\sigma=0.43$

0	1
0	0

0	0
5	5

$\mu=5.00$
 $\sigma=0.00$

5	5
5	5

$\mu=0.00$
 $\sigma=0.00$

0	0
0	0

2	0
4	0

6	4
3	6

$\mu=0.75$
 $\sigma=0.83$

2	1
0	0

7	7
0	0

1	7
0	2

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