



Kantendetektion

Intelligent Scissors



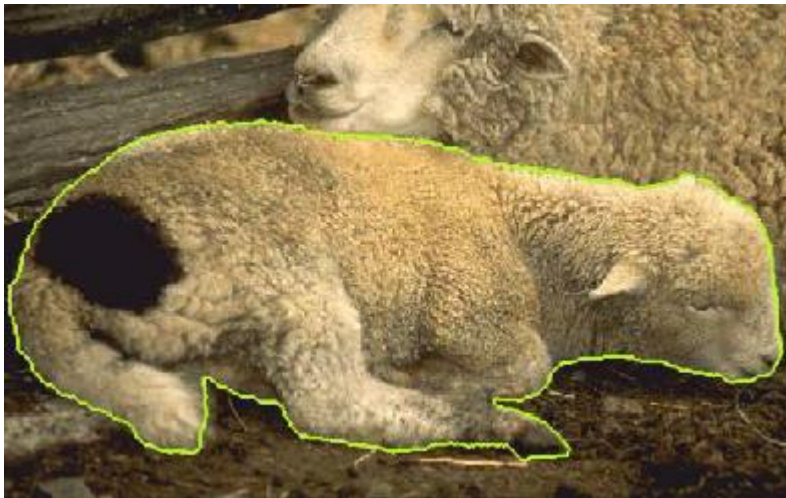
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Image Feature	Formulation
Laplacian Zero-Crossing	f_Z
Gradient Magnitude	f_G
Gradient Direction	f_D

The local costs are computed as a weighted sum of these component functionals. Letting $l(\mathbf{p}, \mathbf{q})$ represents the local cost on the directed link from pixel $\mathbf{p}$ to a neighboring pixel $\mathbf{q}$, the local cost function is

$$l(\mathbf{p}, \mathbf{q}) = \omega_Z \cdot f_Z(\mathbf{q}) + \omega_D \cdot f_D(\mathbf{p}, \mathbf{q}) + \omega_G \cdot f_G(\mathbf{q}) \quad (1)$$

where each ω is the weight of the corresponding feature function. (Empirically, weights of $\omega_Z = 0.43$, $\omega_D = 0.43$, and $\omega_G = 0.14$ seem to work well in a wide range of images.)



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Input:

s {Start (or seed) pixel.}
 $l(q, r)$ {Local cost function for link between pixels q and r .}

Data Structures:

L {List of active pixels sorted by total cost (initially empty).}
 $N(q)$ {Neighborhood set of q (contains 8 neighbors of pixel).}
 $e(q)$ {Boolean function indicating if q has been expanded/processed}.
 $g(q)$ {Total cost function from seed point to q .}

Output:

p {Pointers from each pixel indicating the minimum cost path.}

Algorithm:

```

 $g(s) \leftarrow 0; \quad L \leftarrow s; \quad$  {Initialize active list with zero cost seed pixel.}
while  $L \neq \emptyset$  do begin {While still points to expand;}
     $q \leftarrow \min(L);$  {Remove minimum cost pixel  $q$  from active list.}
     $e(q) \leftarrow \text{TRUE};$  {Mark  $q$  as expanded (i.e., processed).}
    for each  $r \in N(q)$  such that not  $e(r)$  do begin
         $g_{\text{tmp}} \leftarrow g(q) + l(q, r);$  {Compute total cost to neighbor.}
        if  $r \in L$  and  $g_{\text{tmp}} < g(r)$  then {Remove higher cost neighbor's }
             $r \leftarrow L;$  { from list.}
        if  $r \notin L$  then begin {If neighbor not on list, }
             $g(r) \leftarrow g_{\text{tmp}};$  { assign neighbor's total cost, }
             $p(r) \leftarrow q;$  { set (or reset) back pointer, }
             $L \leftarrow r;$  { and place on (or return to) }
        end { active list.}
    end
end
end

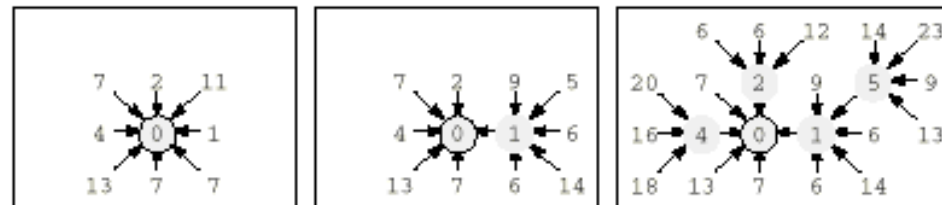
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11	13	12	9	5	8	3	1	2	4	10
14	11	7	4	2	5	8	4	6	3	8
11	6	3	5	7	9	12	11	10	7	4
7	4	6	11	13	18	17	14	8	5	2
6	2	7	10	15	15	21	19	8	3	5
8	3	4	7	9	13	14	15	9	5	6
11	5	2	8	3	4	5	7	2	5	9
12	4	2	1	5	6	3	2	4	8	12
10	9	7	5	9	8	5	3	7	8	15

(a)



Berechnung der optimalen Pfade mit vereinfachten, pixelbasierten Kosten, z.B. aus Gradientenbetrag.

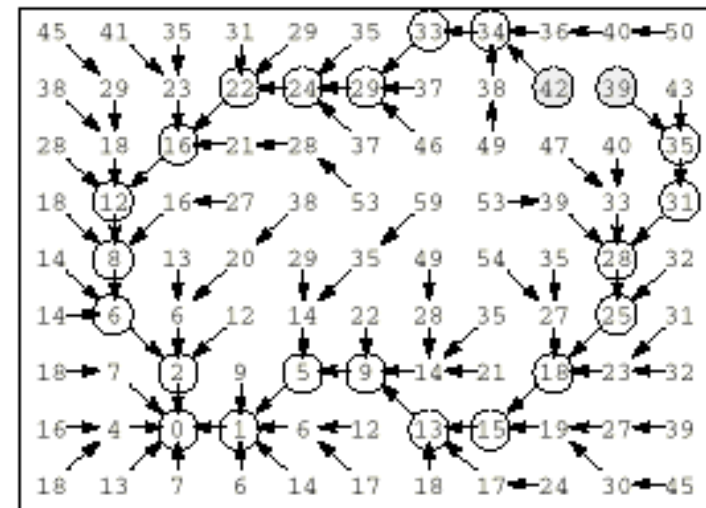
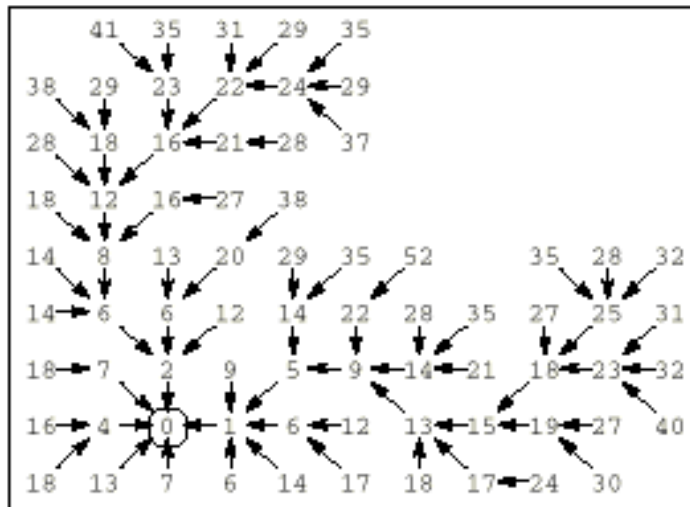
Bei diagonalen Verbindungen wird wegen längerem Weg mit 1,4 multipliziert (aus [Mortensen95]).

In Wirklichkeit werden für jede Verbindung zw. zwei benachbarten Pixeln unterschiedliche Kosten berechnet.

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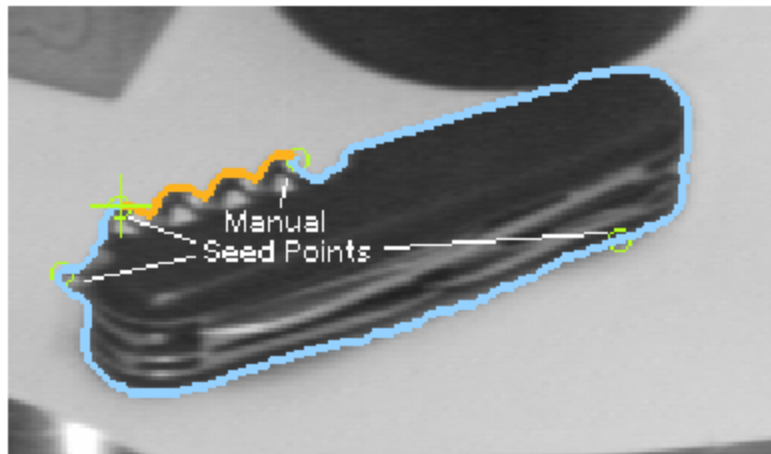
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Zusätzliche Techniken:

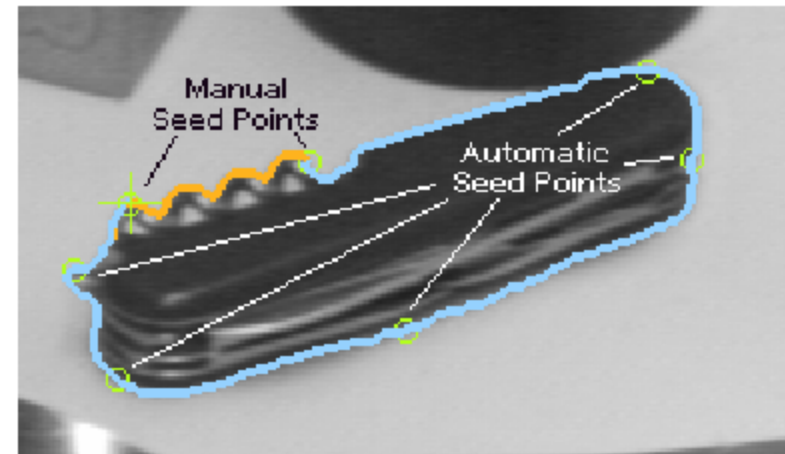
- Cursor snap
- Path Cooling
- Dynamic cost map

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Path Cooling



(a)



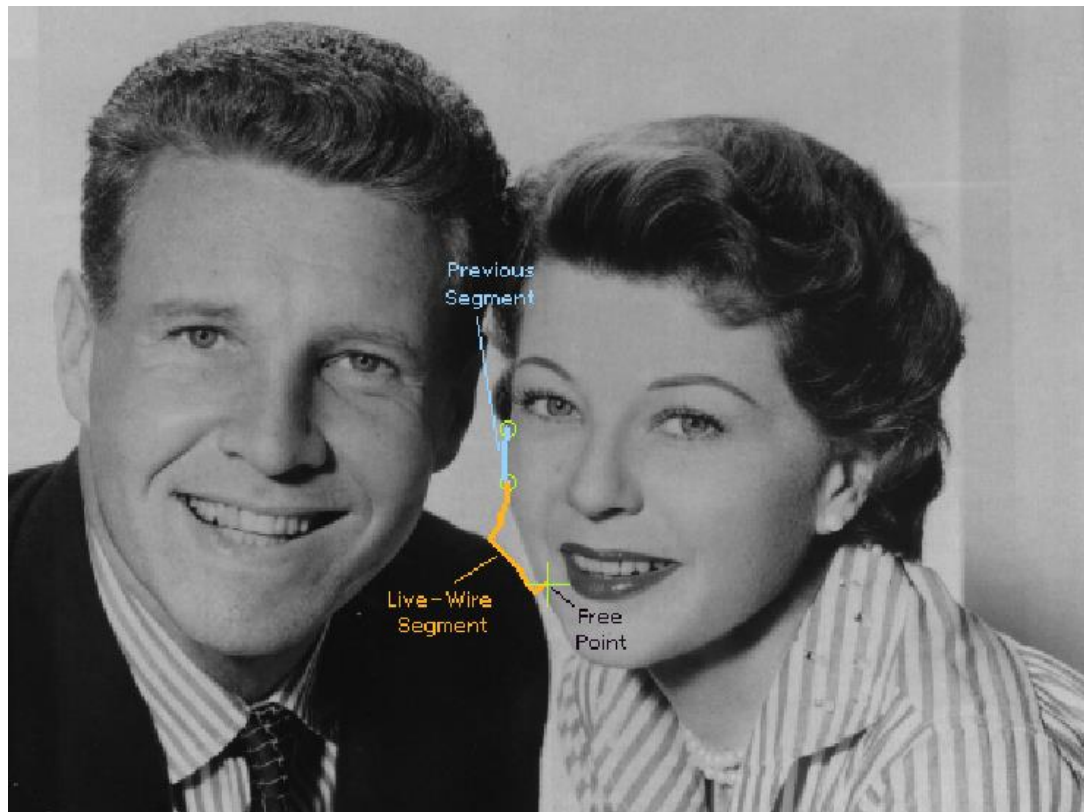
(b)

Figure 3: Comparison of live-wire without (a) and with (b) cooling. Without cooling (a), all seed points must be placed manually on the object edge. With cooling (b), seed points are generated automatically as the live-wire segment freezes.

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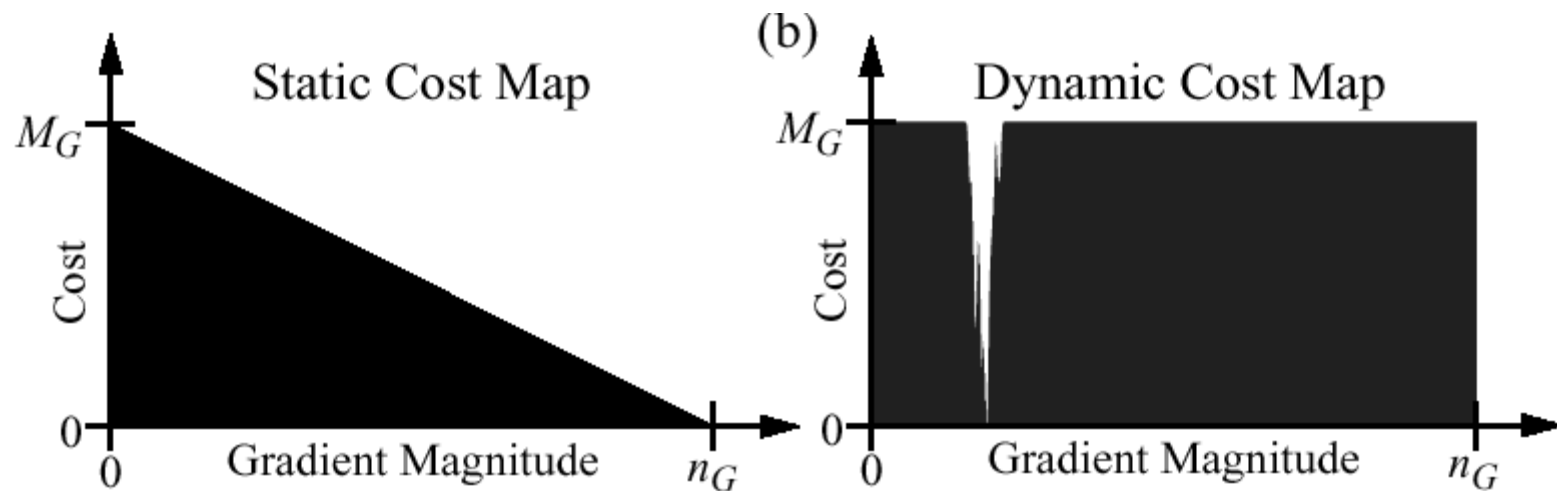
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Dynamic Cost map



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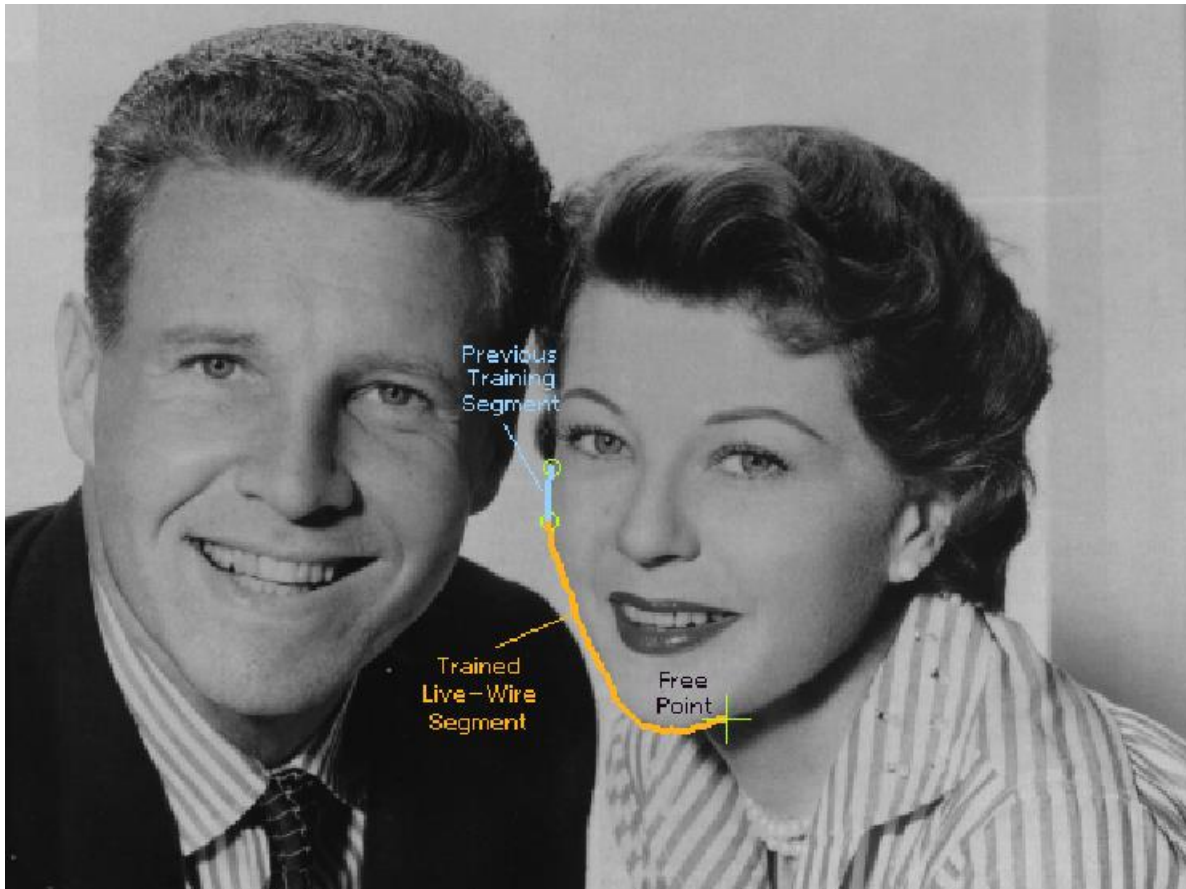
Dynamic Cost map



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Dynamic Cost map



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Demo von Ronen Shor (zum Download):

<http://www.cs.technion.ac.il/~cs234326/projects/scissors/Scissors.html>



Literatur

31.01.2019

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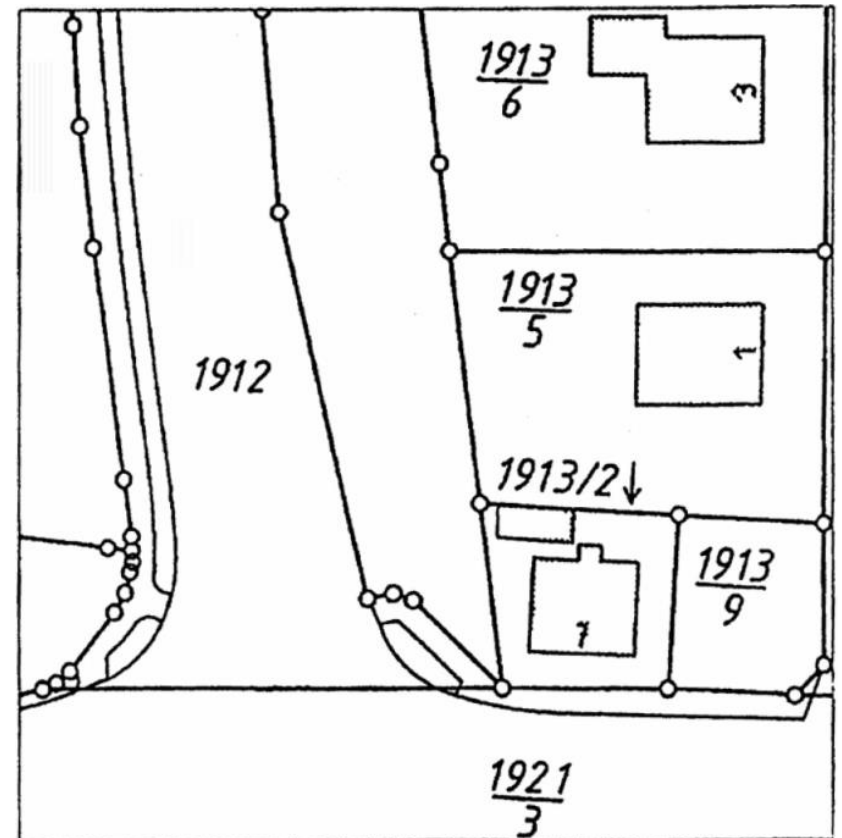
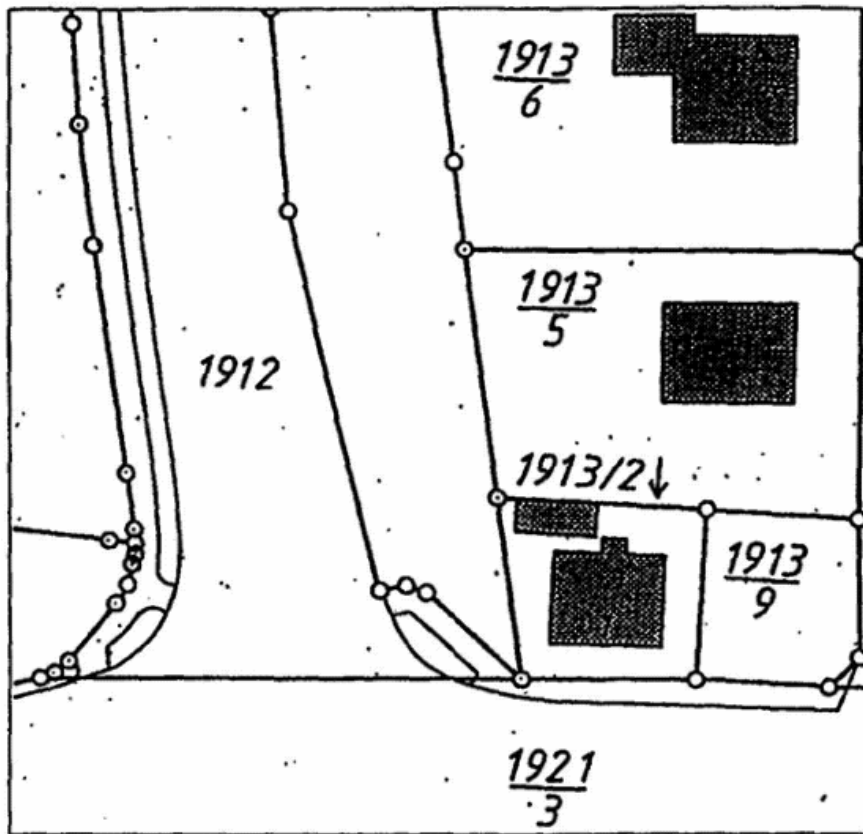
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Morphologische Operatoren



Morphologische Operationen

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Bilder aus Hinz 2003

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Bilder aus Hinz 2003

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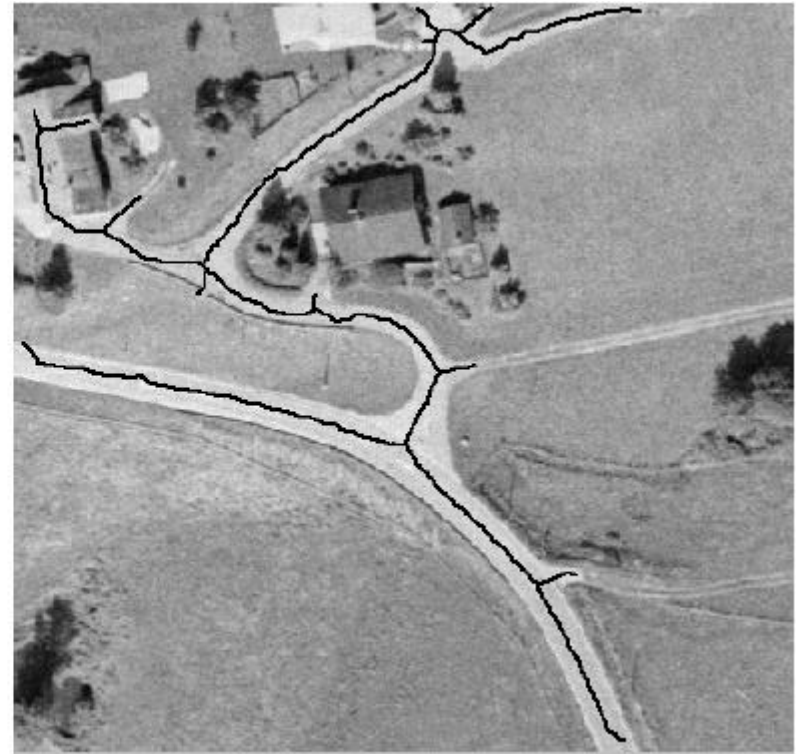
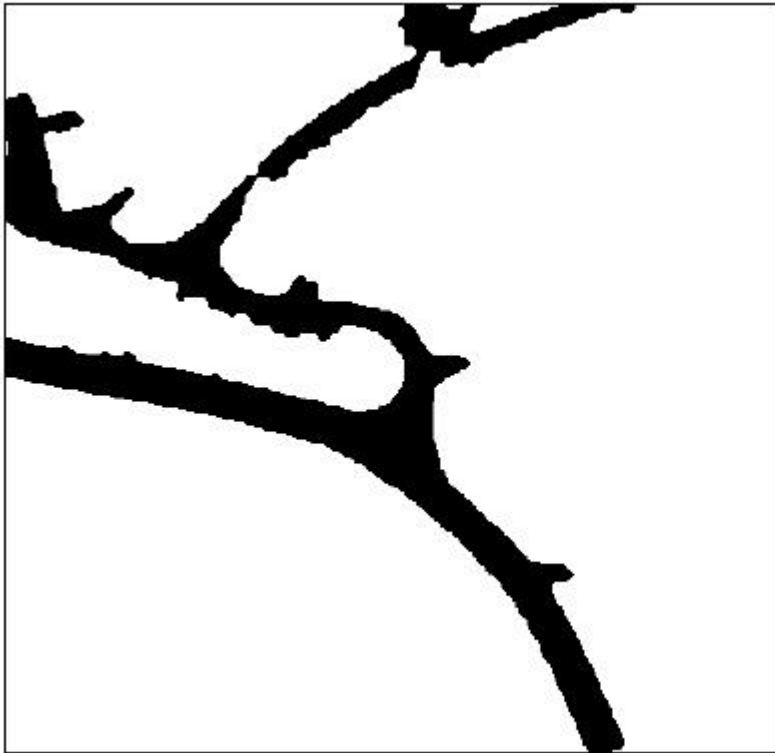
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Bilder aus Hinz 2003

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Bilder aus Hinz 2003



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Grundlagen:

Binäres Pixelbild

$$A \subset \mathbb{Z}^2$$

Strukturelement B

$$B \subset \mathbb{Z}^2$$

Translation:

$$(A)_x = \{a_x \mid a_x = a + x, a \in A\}$$

Komplement:

$$\bar{A} = \{\bar{a} \mid \bar{a} \notin A\}$$

Differenz:

$$A - B = A \cap \bar{B} = \{x \mid x \in A, x \notin B\}$$

Reflektion:

$$\hat{A} = \{\hat{a} \mid \hat{a} = -a, a \in A\}$$



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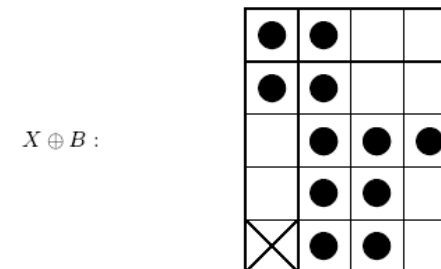
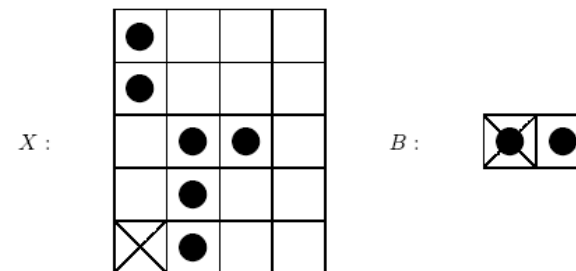
Dilatation (Dilation) der Mengen X und B:

$$X = \{(0, 1), (1, 1), (2, 1), (2, 2), (3, 0), (4, 0)\}$$

$$B = \{(0, 0), (0, 1)\}$$

$$X \oplus B = \{(0, 1), (1, 1), (2, 1), (2, 2), (3, 0), (4, 0), (0, 2), (1, 2), (2, 2), (2, 3), (3, 1), (4, 1)\}$$

$$X \oplus B = \left\{ x \mid \left(\hat{B} \right)_x \cap X \neq \emptyset \right\}$$



Nullpunkt (0, 0)



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Dilatation (Dilation) Anwendung:

- Füllen von Löchern, Schließen von Rissen
- Vereinigung von getrennten Strukturen
- Kantendetektion:

$$(X \oplus B) - X$$

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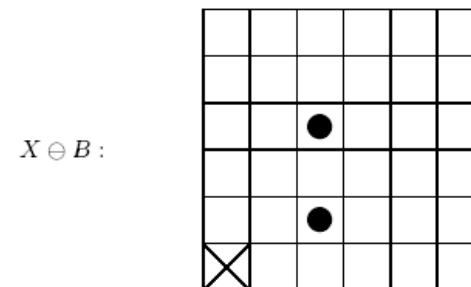
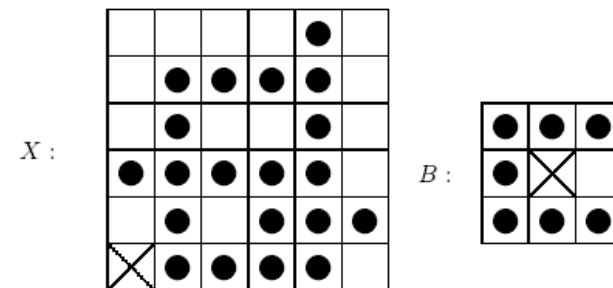
Erosion der Mengen X und B:

$$X = \{(0, 1), (0, 2), (0, 3), (0, 4), (1, 1), (1, 3), (1, 4), (1, 5), (2, 0), (2, 1), (2, 2), (2, 3), (2, 4), (3, 1), (3, 4), (4, 1), (4, 2), (4, 3), (4, 4), (5, 4)\}$$

$$B = \{(-1, -1), (-1, 0), (-1, 1), (0, -1), (1, -1), (1, 0), (1, 1)\}$$

$$X \ominus B = \{(1, 2), (3, 2)\}$$

$$X \ominus B = \{x \mid (B)_x \subseteq A\}$$





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Erosion Anwendung:

- Entfernen von kleinen Elementen
- Kantendetektion:

$$X - (X \ominus B)$$

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Opening (Öffnung):

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

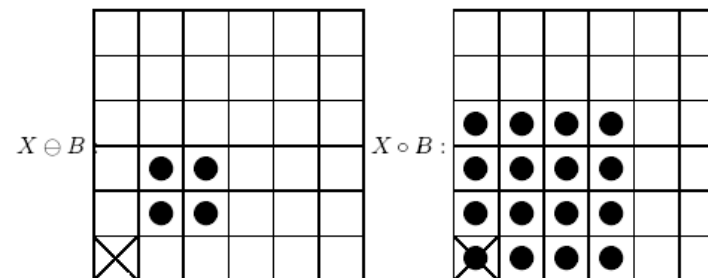
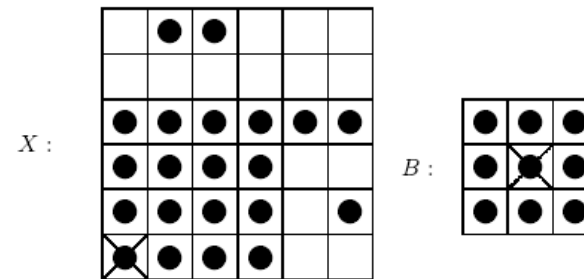
$$X = \{(0,0), \dots, (0,3), (1,0), \dots, (1,3), (1,5), (2,0), \dots, (2,3), (3,0), \dots, (3,5), (5,1), (5,2)\}$$

$$B = \{(-1,-1), \dots, (1,1)\}$$

$$X \ominus B = \{(1,1), (1,2), (2,1), (2,2)\}$$

$$X \circ B = \{(0,0), \dots, (0,3), (1,0), \dots, (1,3), (2,0), \dots, (2,3), (3,0), \dots, (3,3)\}$$

Es gilt: $X \circ B \subseteq X$





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Closing (Abschließung):

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

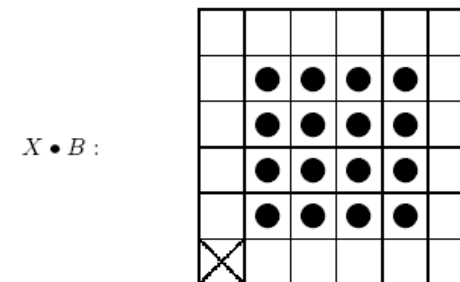
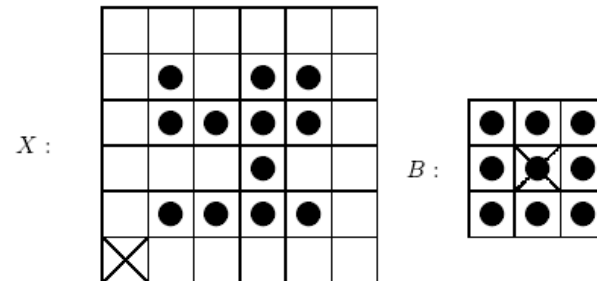
$$X = \{(1,1), (1,2), (1,3), (1,4), (2,3), (3,1), (3,2), (3,3), (3,4), (4,1), (4,3), (4,4)\}$$

$$B = \{(-1,-1), \dots, (1,1)\}$$

$$X \oplus B = \{(0,0), \dots, (5,5)\}$$

$$X \bullet B = \{(1,1), \dots, (1,4), (2,1), \dots, (2,4), (3,1), \dots, (3,4), (4,1), \dots, (4,4)\}$$

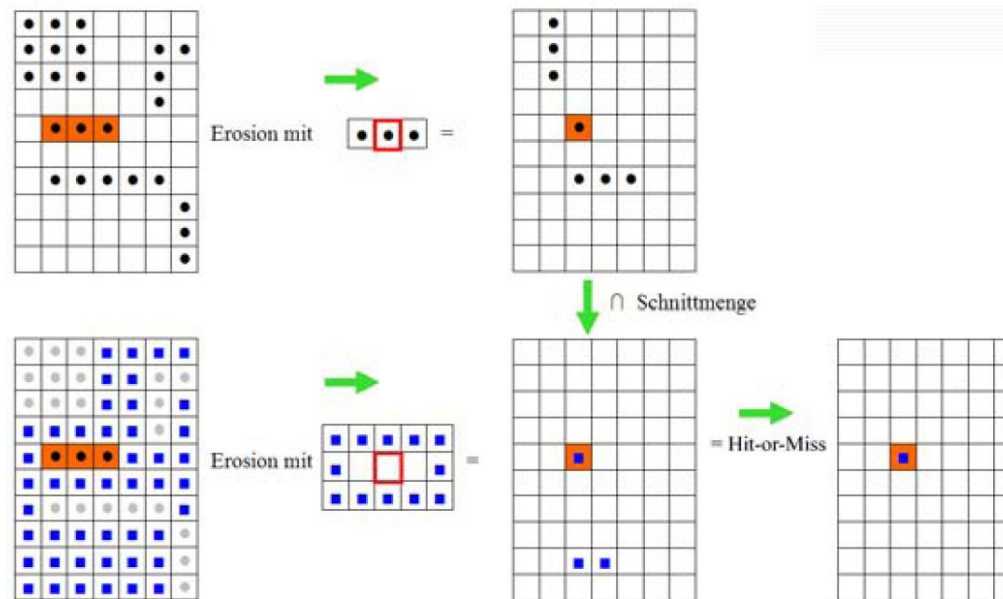
Es gilt: $X \subseteq X \bullet B$



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Anwendungen:
Alles-oder-nichts-Transformation

$$X \otimes B = (X \ominus B_1) \cap (\bar{X} \ominus B_2)$$





Referenzen

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Stefan Hinz: Skript Digitale Bildverarbeitung, TU München 2003

Da die Zeichen in der Vorlesung gefehlt haben, hier nochmal eine Übersicht:

Dilatation:

$$X \oplus B = \left\{ x \mid \left(\hat{B} \right)_x \cap X \neq \emptyset \right\}$$

Erosion:

$$X \ominus B = \left\{ x \mid \left(B \right)_x \subseteq A \right\}$$

Opening:

$$X \circ B = \left(X \ominus B \right) \oplus B$$

Closing:

$$X \bullet B = \left(X \oplus B \right) \ominus B$$