Shape Matching

- Chamfer Matching
- HOG

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Hierarchical Chamfer Matching: A Parametric Edge Matching Algorithm (HCMA)

HCMA

- Chamfer Matching - minimize a generalized distance between two sets of edge points.
  - Parametric transformations

- HCMA is embedded in a resolution pyramid.

Distance Transform: Sequential Algorithm

- Start with zero-infinity image : set each edge pixel to 0 and each non-edge pixel to infinity.
- Make 2 passes over the image with a mask:
  - 1. Forward, from left to right and top to bottom
  - 2. Backward, from right to left and from bottom to top.

d2	d1	d2
d1	0	

Forward Mask

	0	d1
d2	d1	d2

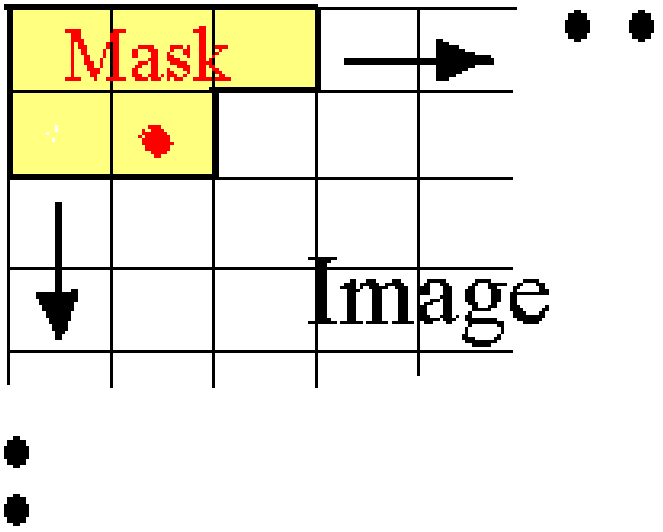
Backward Mask

*d*1 and *d*2, are added to the pixel values in the distance map and the new value of the zero pixel is the minimum of the five sums. (eg., d1=3, d2=4)

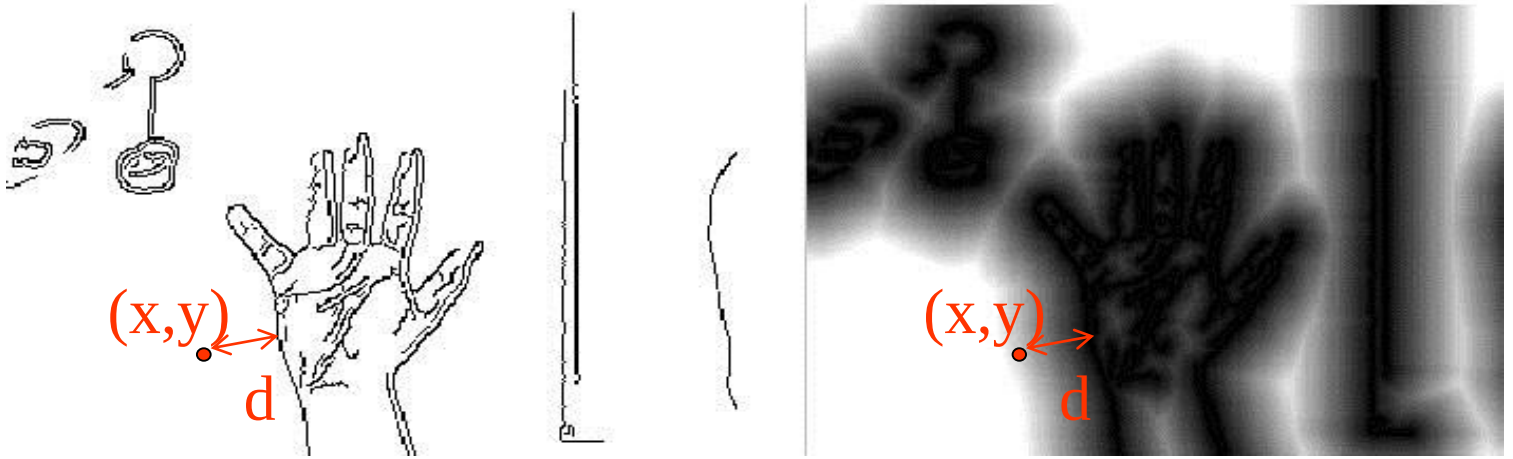
DT Parallel Algorithm

- For each position of mask on image,
- $V_{i,j} = \text{minimum}(v_{i-1,j-1}+d2, v_{i-1,j}+d1, v_{i-1,j+1}+d2, v_{i,j-1}+d1, v_{i,j})$

d2	d1	d2
d1	0	



Distance Transform



- Distance image gives the distance to the nearest edge at every pixel in the image
- Calculated only once for each frame

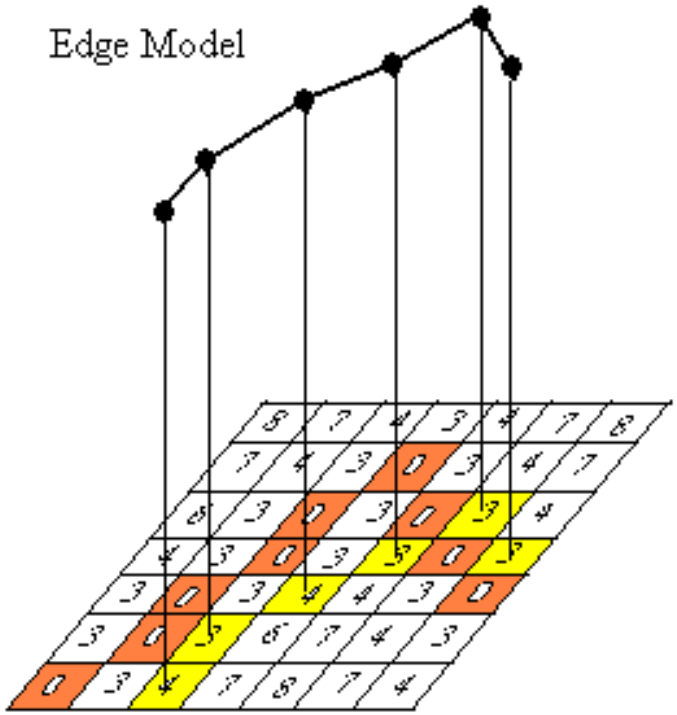
Chamfer Matching

- Edge-model translated over Distance Image.
- At each translation, edge model superimposed on distance image.
- Average of distance values that edge model hits gives Chamfer Distance.

R.M.S. Chamfer Distance =

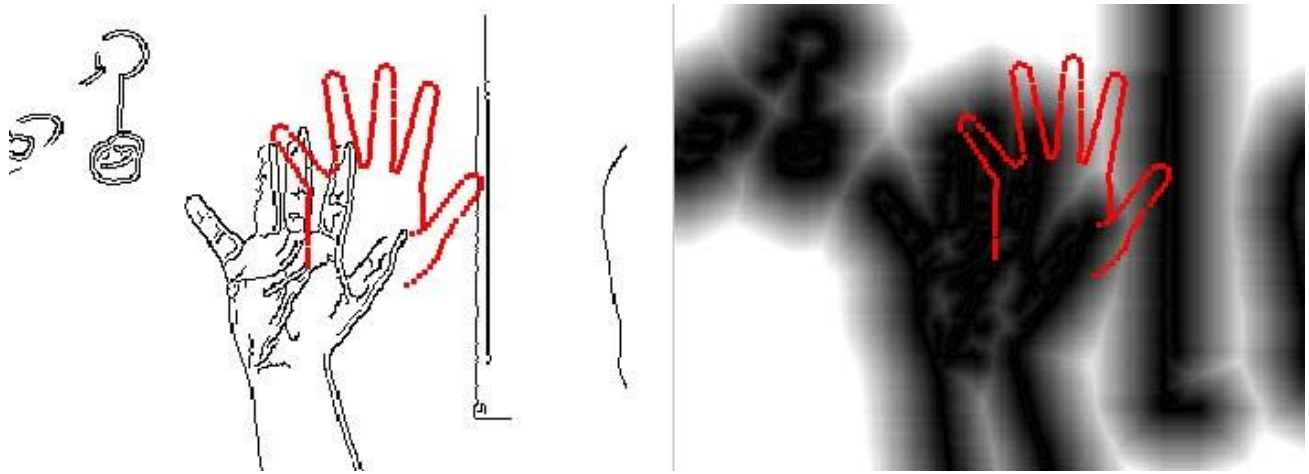
$$\frac{1}{3}\sqrt{\frac{1}{n}\sum_{i=1}^{n} v_i^2}$$

V_i = distance value, n = number of points



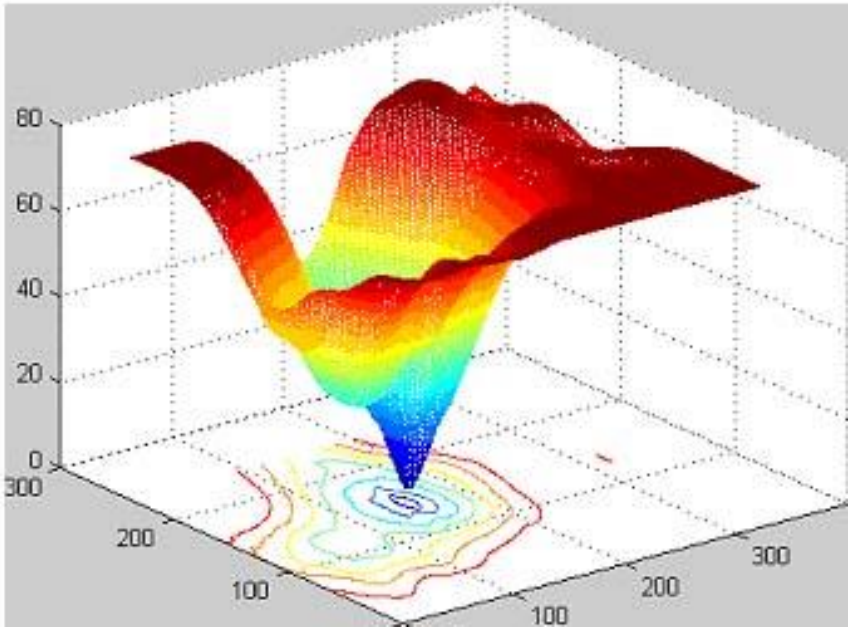
Chamfer Distance = 1.12

Chamfer Matching



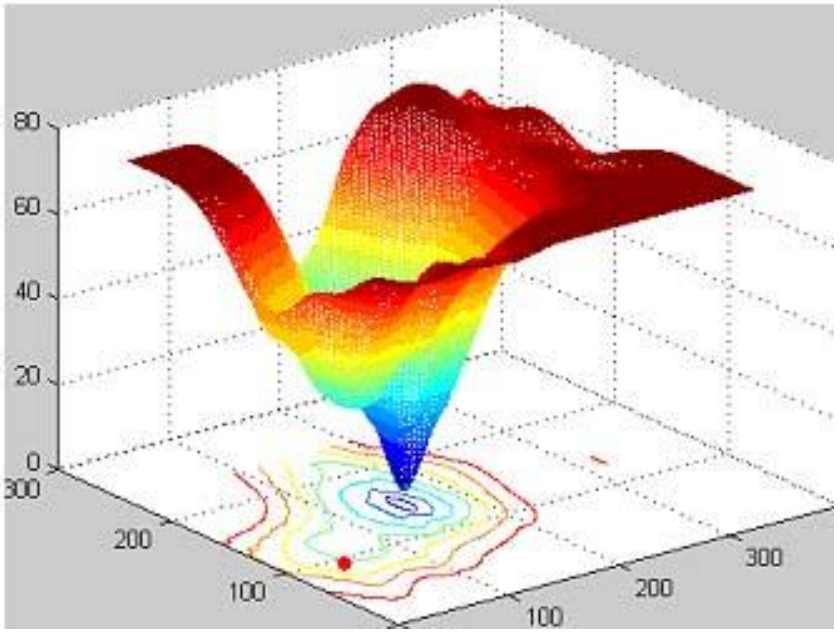
- Chamfer score is average nearest distance from template points to image points
- Nearest distances are readily obtained from the distance image
- Computationally inexpensive

Chamfer Matching

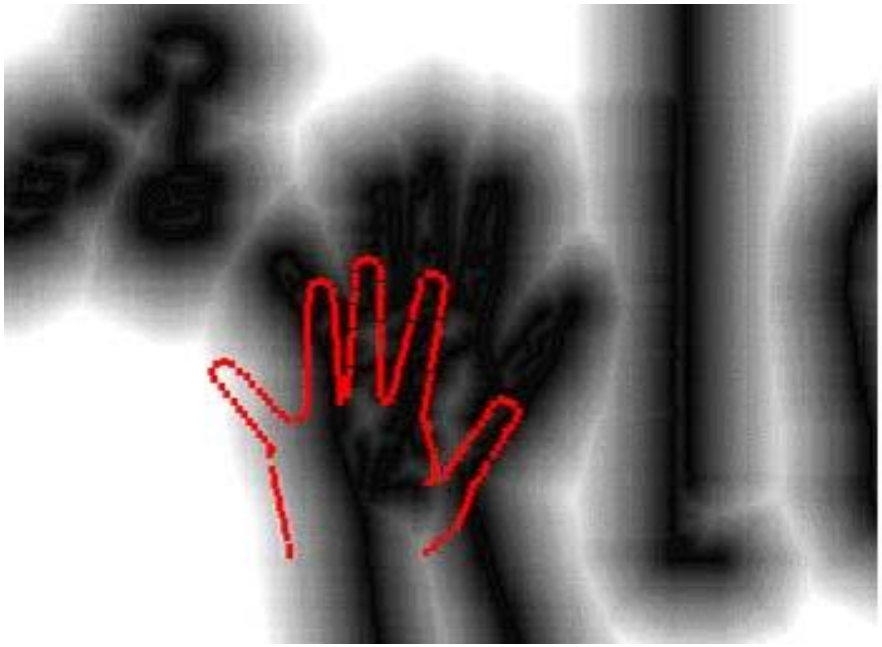


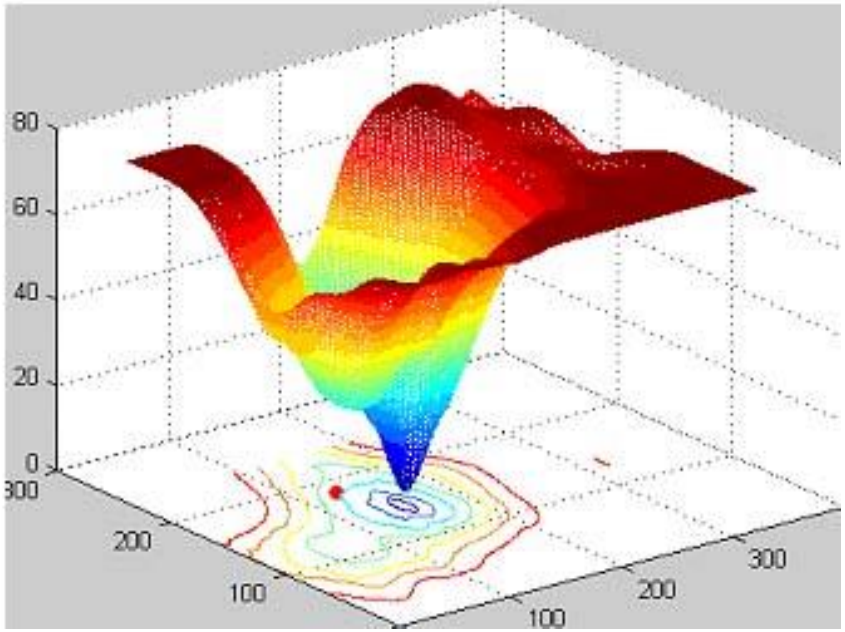
- Distance image provides a smooth cost function
- Efficient searching techniques can be used to find correct template

Chamfer Matching

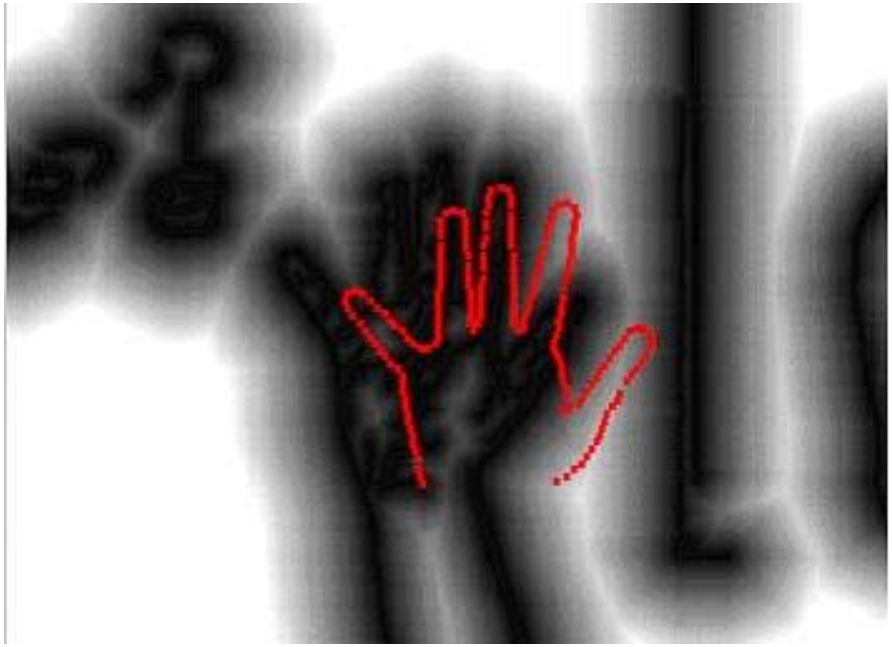


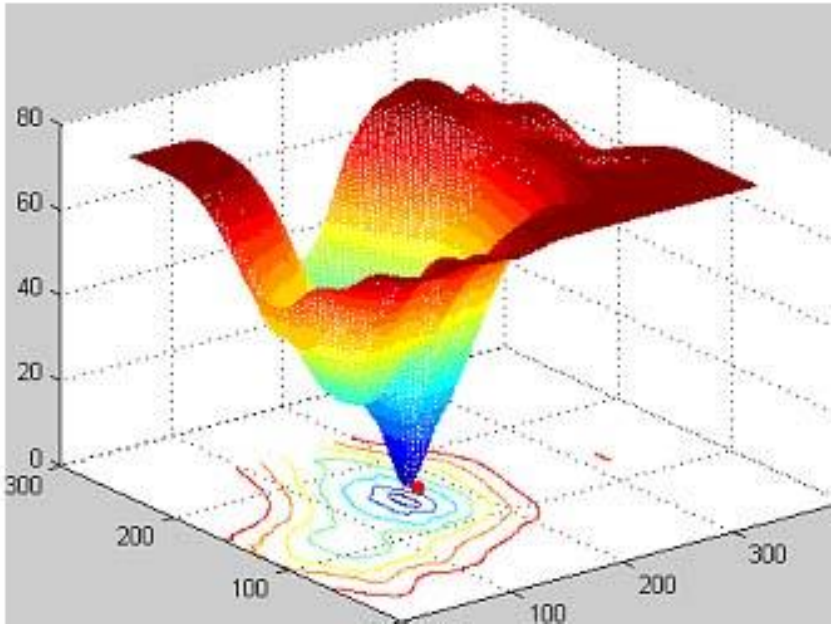
Chamfer Matching



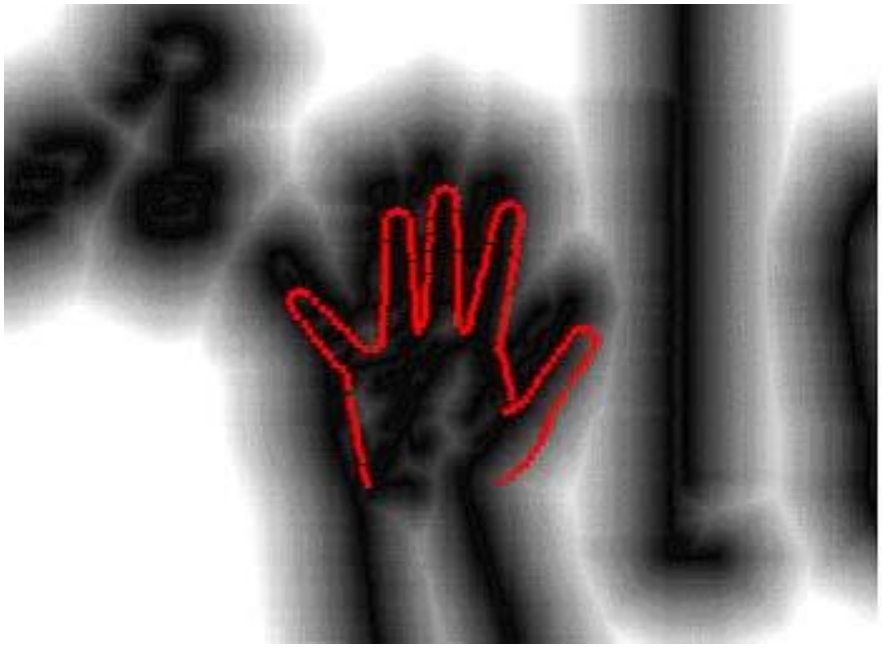


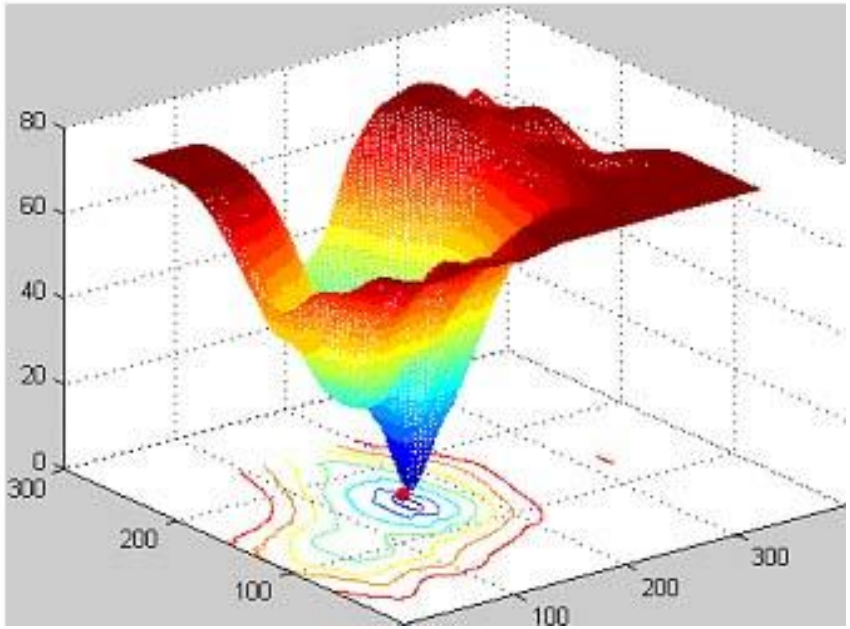
Chamfer Matching



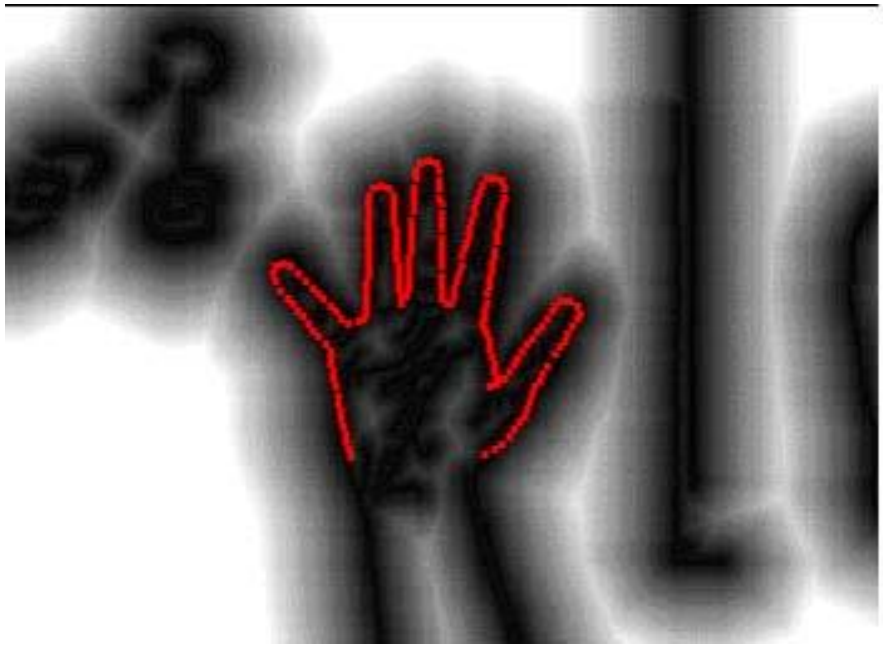


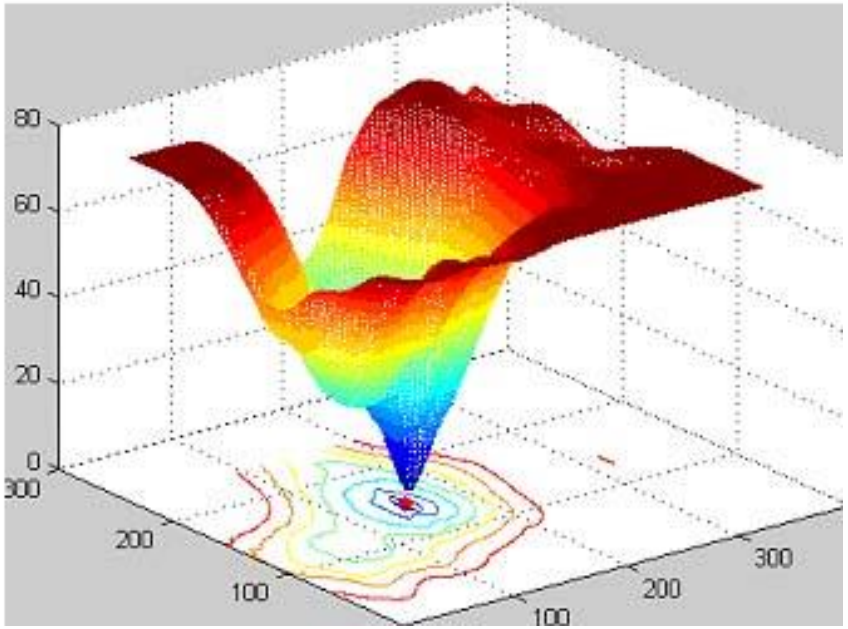
Chamfer Matching





Chamfer Matching





Applications: Hand Detection

- Initializing a hand model for tracking
  - Locate the hand in the image
  - Adapt model parameters
  - No skin color information used
  - Hand is open and roughly fronto-parallel

Results: Hand Detection

Original Shape Context

Shape Context with Continuity Constraint

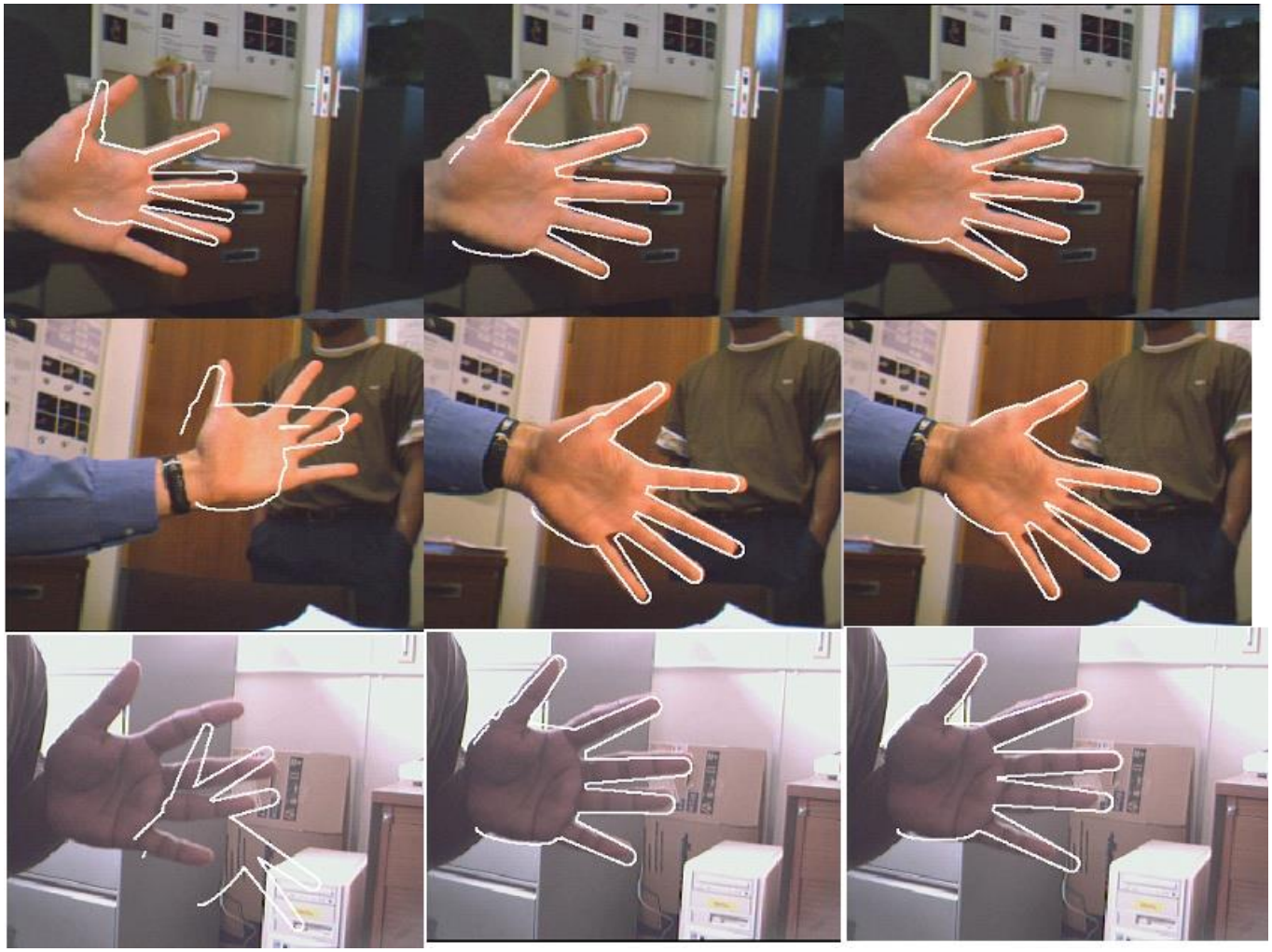
Chamfer Matching

Results: Hand Detection

Original Shape Context

Shape Context with Continuity Constraint

Chamfer Matching



Discussion

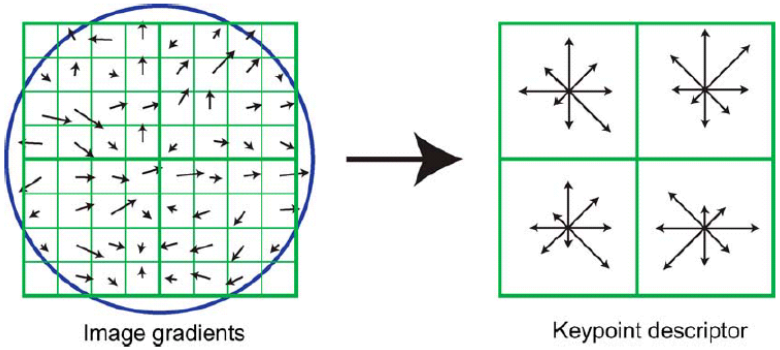
- Chamfer Matching
  - Variant to scale and rotation
  - Sensitive to small shape changes
  - Need large number of template shapes

  But
  - Robust to clutter
  - Computationally cheap

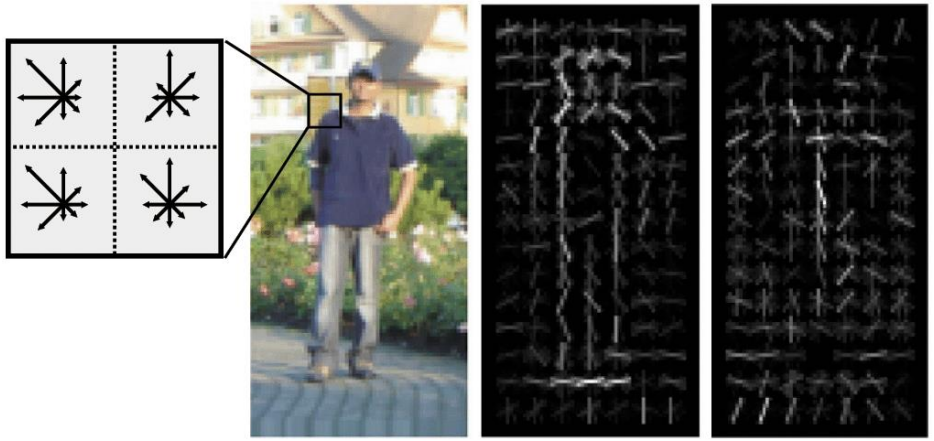
Histogram of Oriented Gradient (HoG)

HOG (1)

- HOG: Histogram of Oriented Gradient
  - Originated by SIFT descriptor
    - SIFT: Texture modeling
    - HOG: Object shapes modeling
  - Modeling dominant orientation in the patch
    - Vector description



SIFT descriptor



HOG descriptor

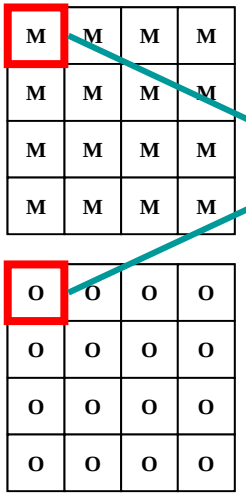
HOG (2)

- Calculation of Gradient Orientations

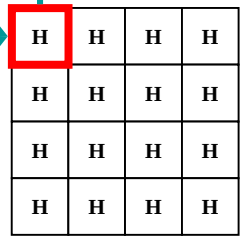
$$dx = L_{x+1,y} - L_{x-1,y}$$
$$dy = L_{x,y+1} - L_{x,y-1}$$

$$m = \sqrt{dx^2 + dy^2}$$

$$\theta = \tan^{-1}(dy / dx)$$



8 Orientation



Orientation Histogram

×

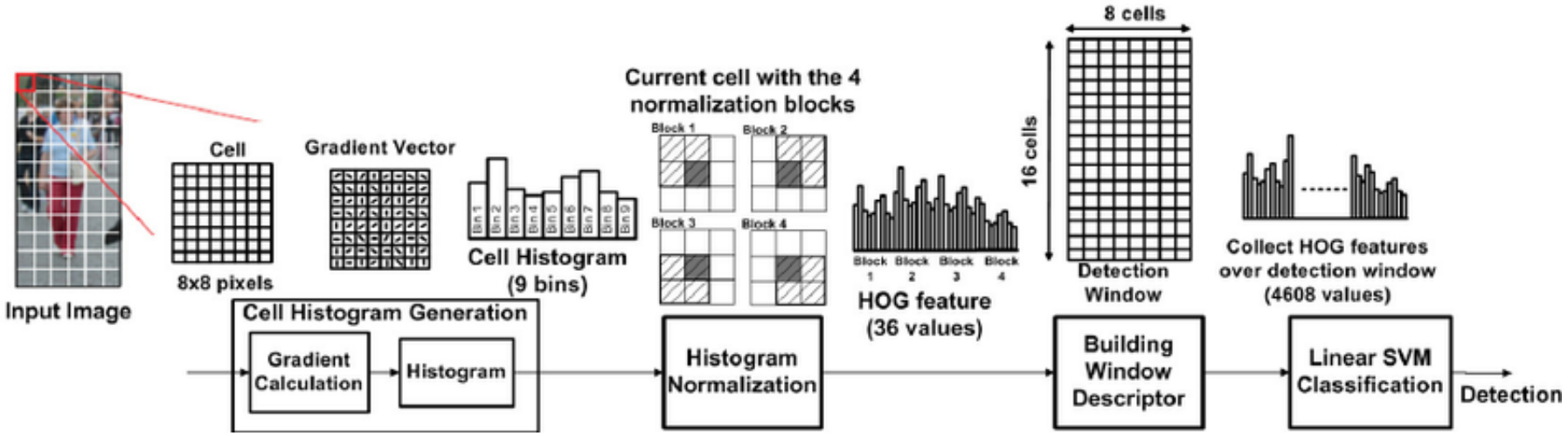
Gaussian Weight

Local feature of object region

HOG (3)

❖HOG Generation

- **Similar to SIFT descriptor**



HOG (4)

❖Example: Human modeling

- **HOG Vector space modeling**
  - Elliptical shape – centroid, vector distance
  - Non-elliptical shape: SVM