8.4 Object Recognition in Videos

- Object Segmentation
- Classification of Objects
- Some Experimental Results

Goal and Challenges

- Goal: Recognition of postures and gestures in videos
- Major challenges:
  * Camera motion
  * Noise

Segmentation (1)

frames

↓

Camera Motion

- Assumption: At least half of the visible area in each frame is background.
- Estimate the camera motion between consecutive frames.
- Calculate parameters of the camera model:

$$x' = \frac{a_{11}x + a_{12}y + t_x}{p_x x + p_y y + 1} \qquad y' = \frac{a_{21}x + a_{22}y + t_y}{p_x x + p_y y + 1}$$

Segmentation (2)

frames

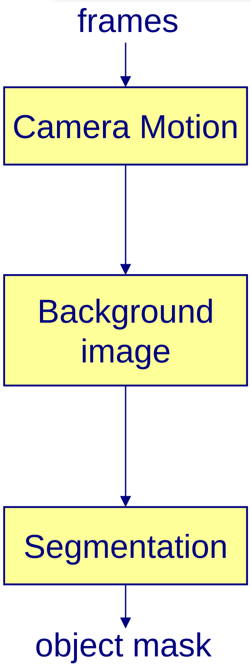
↓

Camera Motion

- Assumption: At least half of the visible area in each frame is background.
- Estimate the camera motion between consecutive frames.
- Calculate parameters of the camera model:

$$x' = \frac{a_{11}x + a_{12}y + t_x}{p_x x + p_y y + 1} \qquad y' = \frac{a_{21}x + a_{22}y + t_y}{p_x x + p_y y + 1}$$

Segmentation (3)

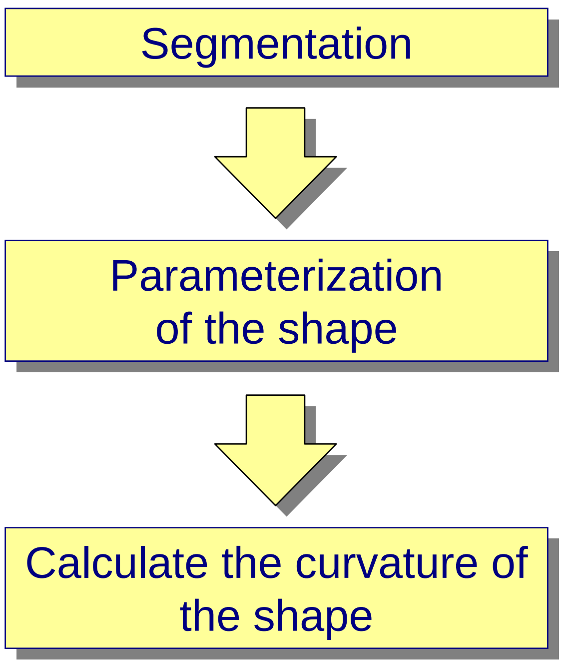


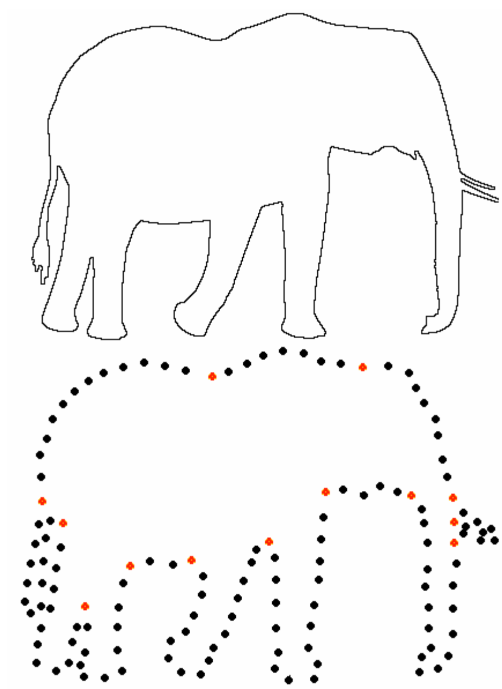
- Assumption: At least half of the visible area in each frame is background.
- Estimate the camera motion between consecutive frames.
- Calculate parameters of the camera model:

$$x' = \frac{a_{11}x + a_{12}y + t_x}{p_x x + p_y y + 1} \qquad y' = \frac{a_{21}x + a_{22}y + t_y}{p_x x + p_y y + 1}$$

- Apply a median filter on the transformed frames to construct the background image.
- Compare the background image with transformed frame to get the object mask.

Calculate Shape Features



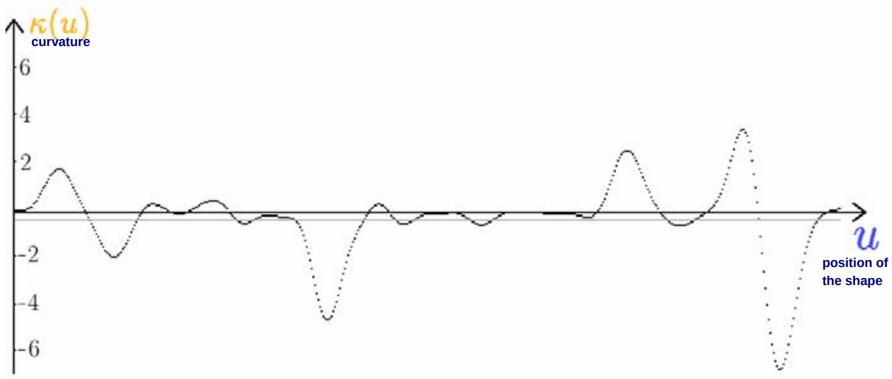


Definition of the Curvature

Definition
of the curvature

$$\kappa = \frac{\ddot{x}\cdot\dot{y}^2 - 2\cdot\dot{x}\cdot\dot{y}\cdot\dot{x}\dot{y} + \ddot{y}\cdot\dot{x}^2}{\dot{x}^2+\dot{y}^2}$$

Curvature function



Calculation of the curvature (1)

Calculate curvature with first and second derivatives

$$\kappa = \frac{\ddot{x}\cdot\dot{y}^2 - 2\cdot\dot{x}\cdot\dot{y}\cdot\dot{x}\dot{y} + \ddot{y}\cdot\dot{x}^2}{\dot{x}^2+\dot{y}^2}$$

First derivatives

$$\dot{x}_{i,j} = \frac{P_{i+1,j} - P_{i-1,j}}{2\cdot hx}$$

$$\dot{y}_{i,j} = \frac{P_{i,j+1} - P_{i,j-1}}{2\cdot hy}$$

Calculation of the curvature (2)

Second derivative

$$\ddot{x}_{i,j} = \frac{P_{i+1,j} - 2 \cdot P_{i,j} + P_{i-1,j}}{hx \cdot hx}$$

Derivative in xy-direction

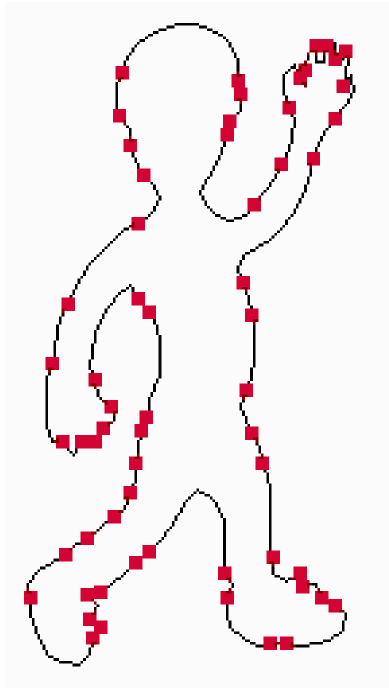
$$M = \frac{1}{2 \cdot hx \cdot hy} \begin{cases} \begin{pmatrix} 0 & -1 & 1 \\ -1 & 2 & -1 \\ 1 & -1 & 0 \end{pmatrix} & \text{for each } \dot{x} \cdot \dot{y} < 0 \\ \begin{pmatrix} -1 & 1 & 0 \\ 1 & -2 & 1 \\ 0 & 1 & -1 \end{pmatrix} & \text{else} \end{cases}$$

Object Classification: Curvature Scale Space

- Analyze the outer shape of an object.
- Smooth the shape with a Gaussian kernel in a sequence of iterations.
- The inflection points in each iteration are used as features to describe the object.

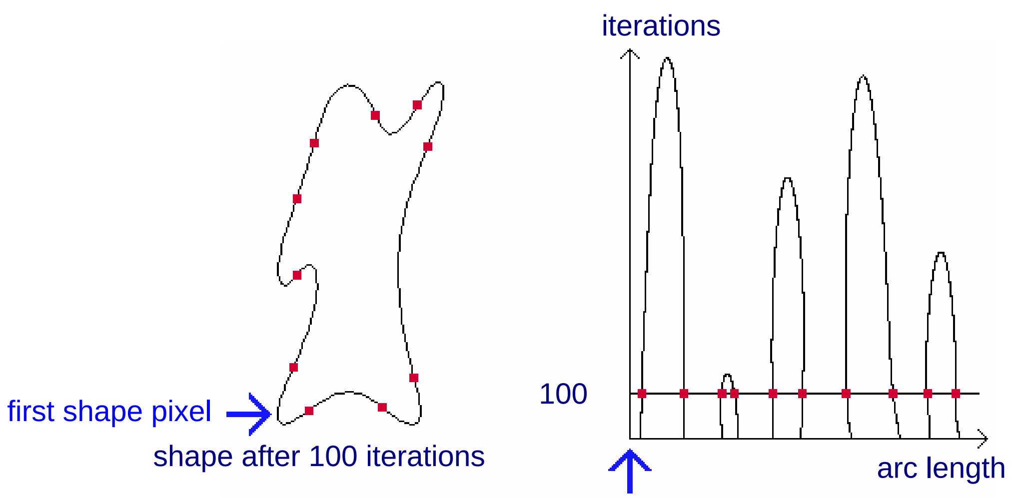
Curvature Scale Space: Smoothing in Iterations

- Analyze the outer shape of an object.
- Smooth the shape with a Gaussian kernel in a sequence of iterations.
- The inflection points in each iteration are used as features to describe the object.



Curvature Scale Space Diagram

- A curvature scale space diagram is a visual representation of the inflection points during the smoothing process.



- The peaks are used as features to describe the object.

Properties of the Curvature Scale Space

- Pro:
  - * Only a few values are required to describe a complex object.
  - * The approach is invariant to rotation or scaling.
  - * Low computation time.
- Contra:
  - * Bad classification results with some shapes.

Ambiguities of Curvature Scale Space Images (1)

Shallow vs. deep concavities:

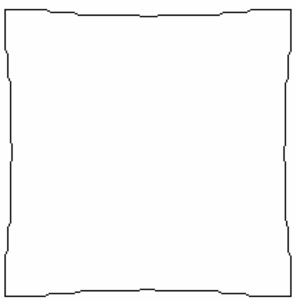


Figure 1

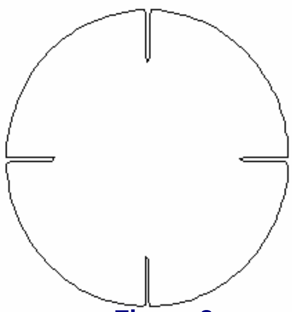
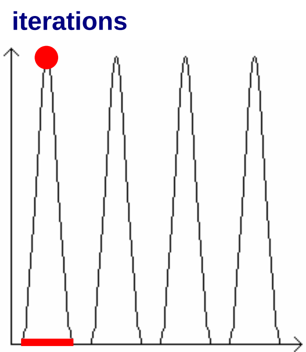
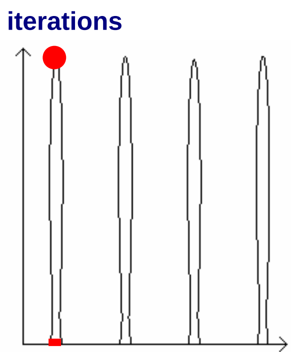


Figure 2



Scale Space Image 1

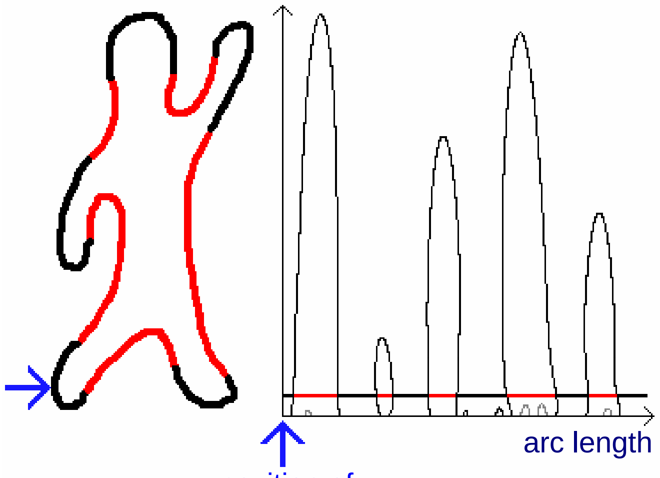


Scale Space Image 2

Solution: Use position, height and width of each peak as a feature.

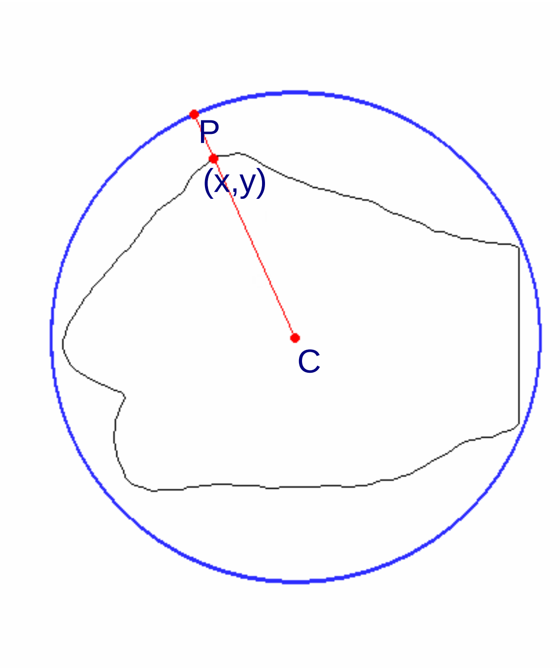
Ambiguities of Curvature Scale Space Images (2)

- Poor representation of convex regions of a shape: convex objects are not represented at all.
- Solution: **Mapped shapes**



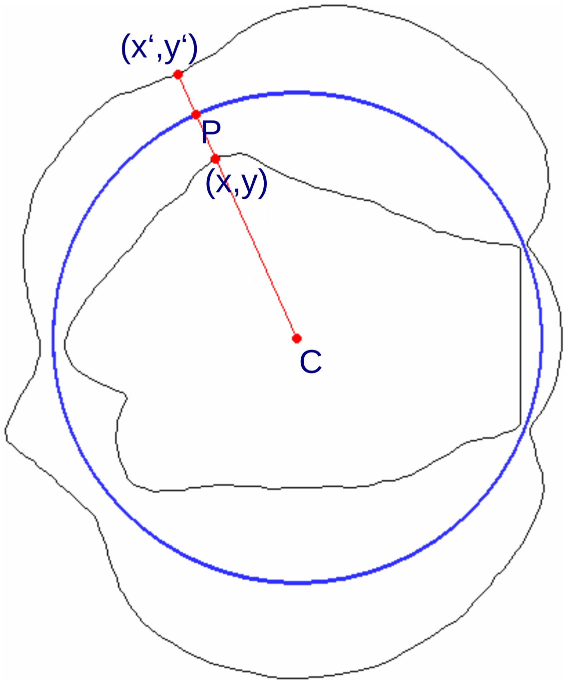
Mapped Shapes (1)

- Idea: mirror each contour pixel at a circle around the object



Mapped Shapes (2)

- Idea: mirror each contour pixel at a circle around the object
- Strong convex segments of the original shape become concave segments of the *mapped shape*.

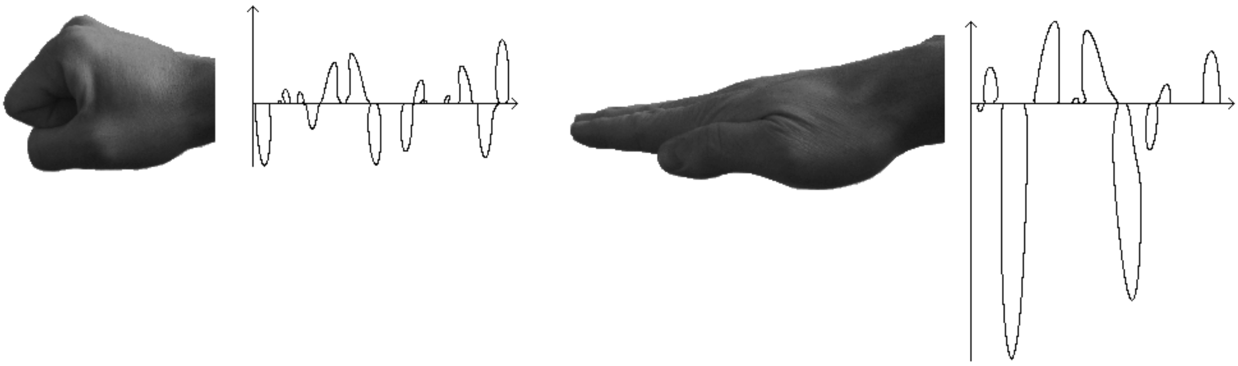


Curvature Scale Space Diagrams

- Calculate standard curvature scale space features.

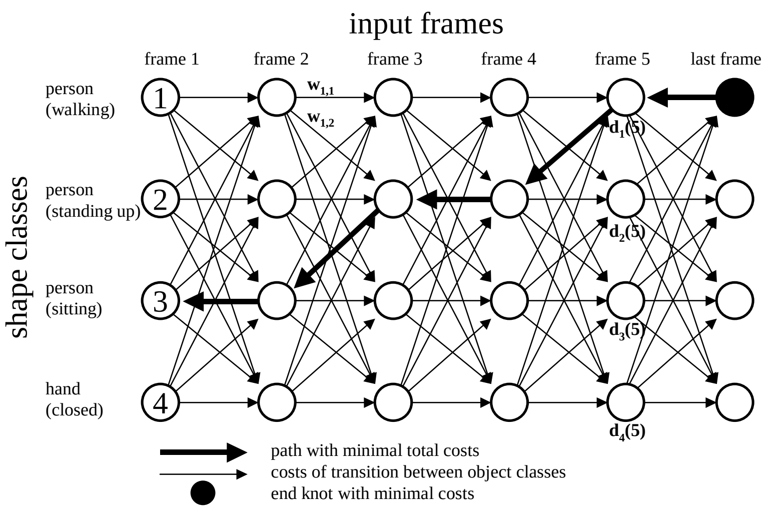
Add the Curvature Scale for the Mapped Shapes

- Calculate standard curvature scale space features.
- Calculate features for the mapped shape.



Aggregation of the Classification Results

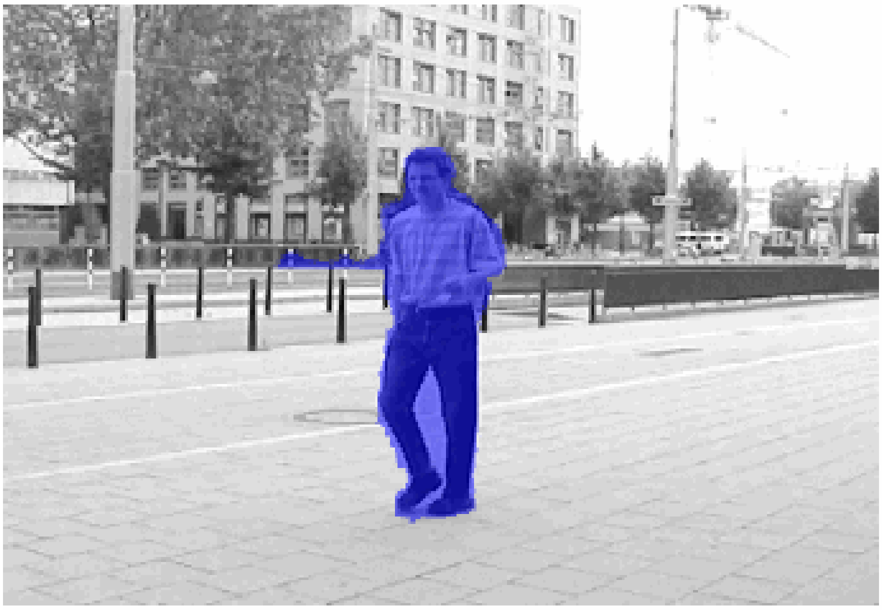
- Similar objects are grouped in one object class.
- Distance between input object *i* and object class *c*: $d_c(i)$
- Transition costs occur for each change of the object class: $w_{n,m}$



- Solve the minimization problem:

$$\min_{c} \sum_{i=1}^{N} (d_{c(i)}(i) + w_{c(i),c(i-1)})$$

Experimental Results



Conclusions

- New algorithms to classify postures and gestures of a person in a video were developed at U. Mannheim.
- A major deficiency of the curvature scale space approach is the fact that convex regions of a shape are not represented in the CSS diagram.
- We propose *mapped shapes,* mirrored at a circle around the object, to overcome this problem.