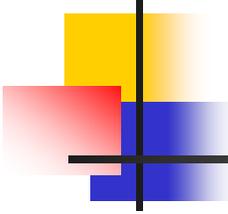
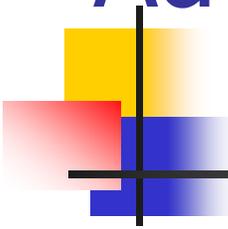


Advanced Image Matching Methods



Presented by:
Dr.Hamid Ebadi

Advanced Image Matching Methods



- Introduction
 - Reliability of Approach
- Extracted Features
 - Interest Points
 - Edges
 - Regions
 - Shapes
- Methods
 - Feature & Shape Based approach
 - Relational Based Approach

Flowchart of Shape Based Matching

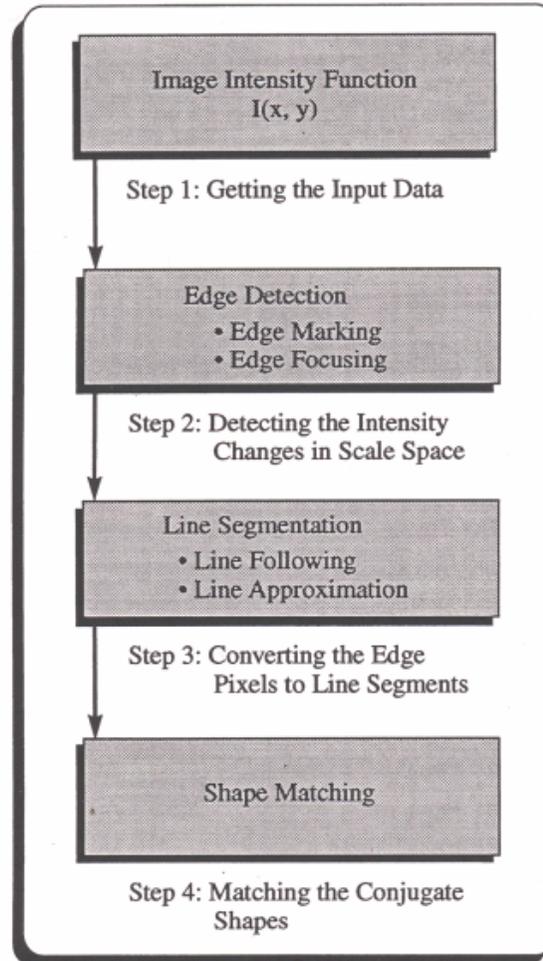
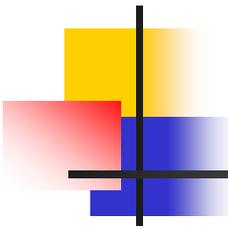


Figure 3.1: Shape-Based Matching Procedure



Feature-Based Matching

- FBM employs as conjugate entities features extracted from the original gray levels
 - Edges are the most important features
 - Stereo vision of Human eye is based on finding conjugate edges

Feature Extraction

■ Interest Points

- To identify areas with high variance
- Interest operator performs the extraction process
- Points with distinct features are called interest points

■ Operators

■ Moravec

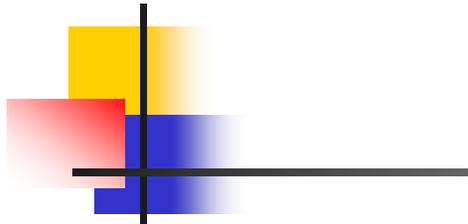
- (measures distinctness of an image patch compared to its surroundings)

$$E_w(x, y) = \sum_{u,v} w_{u,v} |I_{x+u, y+v} - I_{u,v}|^2$$

■ Forstner

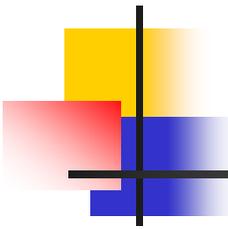
- (Rotation invariant and sub-pixel accuracy)
- Corner points and Circular features are detected

$$N = \begin{bmatrix} \sum g_x^2 & \sum g_x g_y \\ \sum g_x g_y & \sum g_y^2 \end{bmatrix} \quad w = \frac{\det N}{\text{trace} N} \quad q = \frac{4 \det N}{\text{trace}^2 N}$$



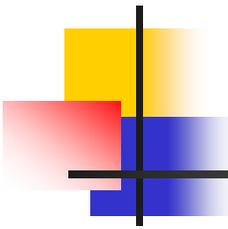
	g_x	g_y																		
Normal Gradient	<table border="1"><tr><td>-1</td><td>1</td></tr></table>	-1	1	<table border="1"><tr><td>1</td></tr><tr><td>-1</td></tr></table>	1	-1														
-1	1																			
1																				
-1																				
Roberts Operator	<table border="1"><tr><td>0</td><td>1</td></tr><tr><td>-1</td><td>0</td></tr></table>	0	1	-1	0	<table border="1"><tr><td>1</td><td>0</td></tr><tr><td>0</td><td>-1</td></tr></table>	1	0	0	-1										
0	1																			
-1	0																			
1	0																			
0	-1																			
Prewitt Operator	<table border="1"><tr><td>-1</td><td>0</td><td>1</td></tr><tr><td>-1</td><td>0</td><td>1</td></tr><tr><td>-1</td><td>0</td><td>1</td></tr></table>	-1	0	1	-1	0	1	-1	0	1	<table border="1"><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>-1</td><td>-1</td><td>-1</td></tr></table>	1	1	1	0	0	0	-1	-1	-1
-1	0	1																		
-1	0	1																		
-1	0	1																		
1	1	1																		
0	0	0																		
-1	-1	-1																		
Sobel Operator	<table border="1"><tr><td>-1</td><td>0</td><td>1</td></tr><tr><td>-2</td><td>0</td><td>2</td></tr><tr><td>-1</td><td>0</td><td>1</td></tr></table>	-1	0	1	-2	0	2	-1	0	1	<table border="1"><tr><td>1</td><td>2</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>-1</td><td>-2</td><td>-1</td></tr></table>	1	2	1	0	0	0	-1	-2	-1
-1	0	1																		
-2	0	2																		
-1	0	1																		
1	2	1																		
0	0	0																		
-1	-2	-1																		

Table 2.3: Some Gradient Operators



Extracted interest points





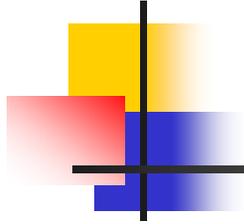
Feature Extraction

- Edge Detection
 - Involves the identification of edge pixels and grouping of edge pixels into entire edges
 - Edges correspond to brightness differences in the images
 - Sharp edges
 - Smooth edges
 - Edges occur at all orientations requiring a direction independent operator
 - n-order differences

Extracted Edges (LoG operator applied)

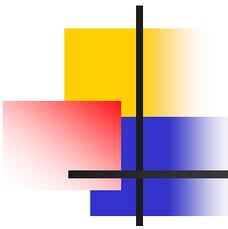


Feature Extraction



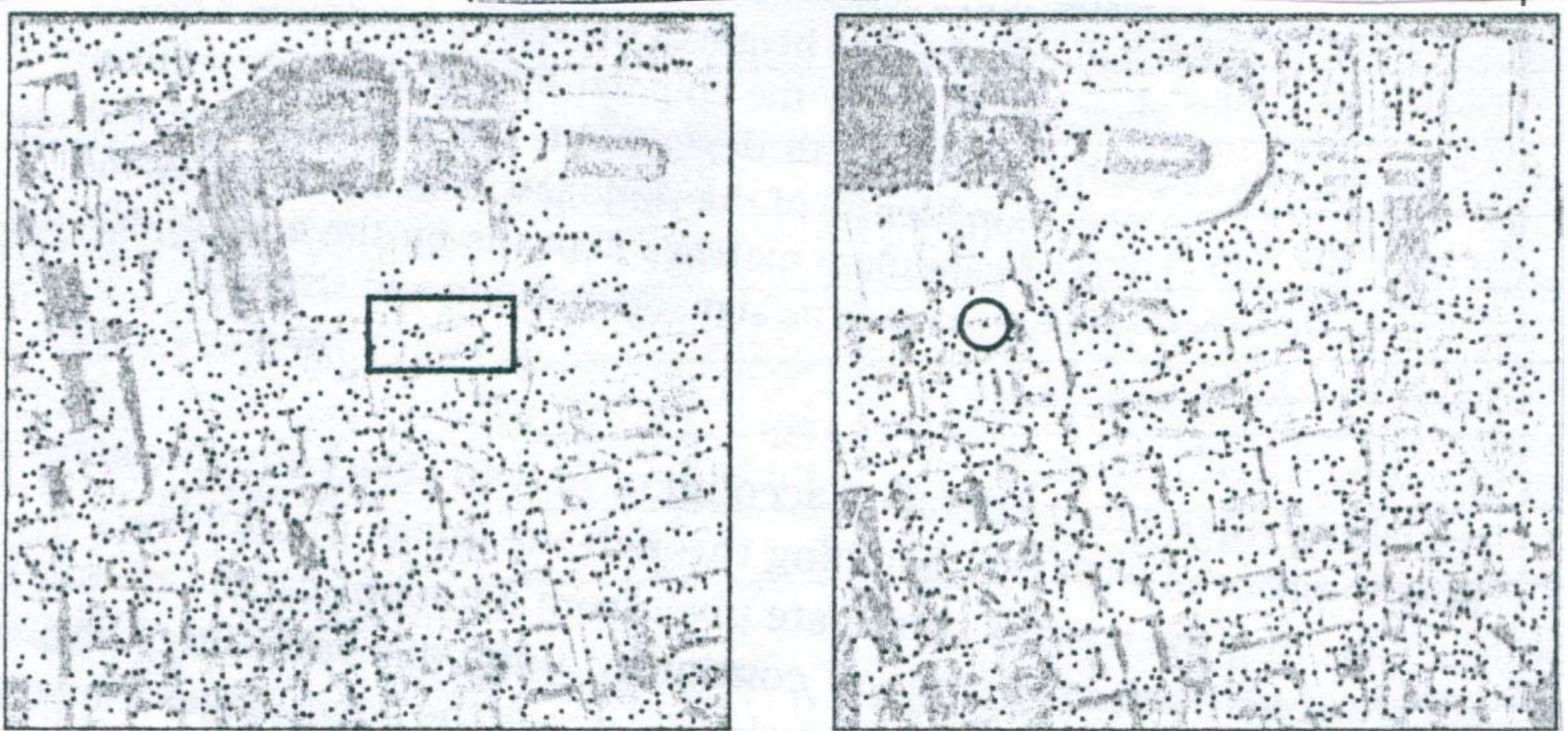
- Extracting Regions
 - To find areas in an image which are small, distinct, and invariant to illumination differences and perspective views
 - Image segmentation
 - Histogram thresholding
 - Texture segmentation

Matching Interest Points

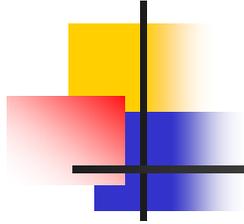


- ABM is the easiest way
- More logical than ABM applied on the original image
- Problems
 - Forshortening, breaklines, occolusion

Matching Interest Points (Forstner operator applied)



Matching Edge Pixels



- Matching Scenario
 - To Normalize the images
 - To Determine Search window in the matching patch (Its centre and dimension)
 - To eliminate some candidates based on incompatible attributes (sign of Zero crossing, orientation, strength)
 - To determine all pixel parallaxes between pixel to be matched and candidate matches
 - Dominant parallaxes can be found by analyzing the histogram of all possible parallaxes
 - To consider additional edge attributes for solving ambiguous situations (strength)

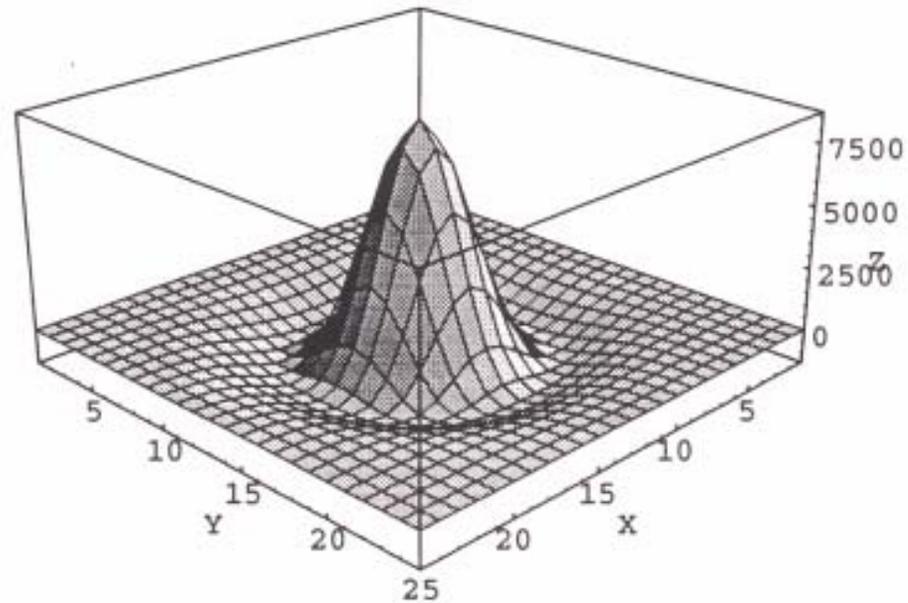
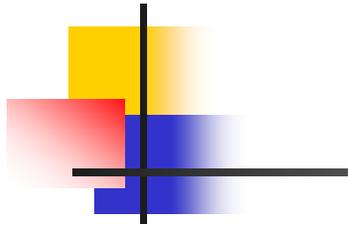
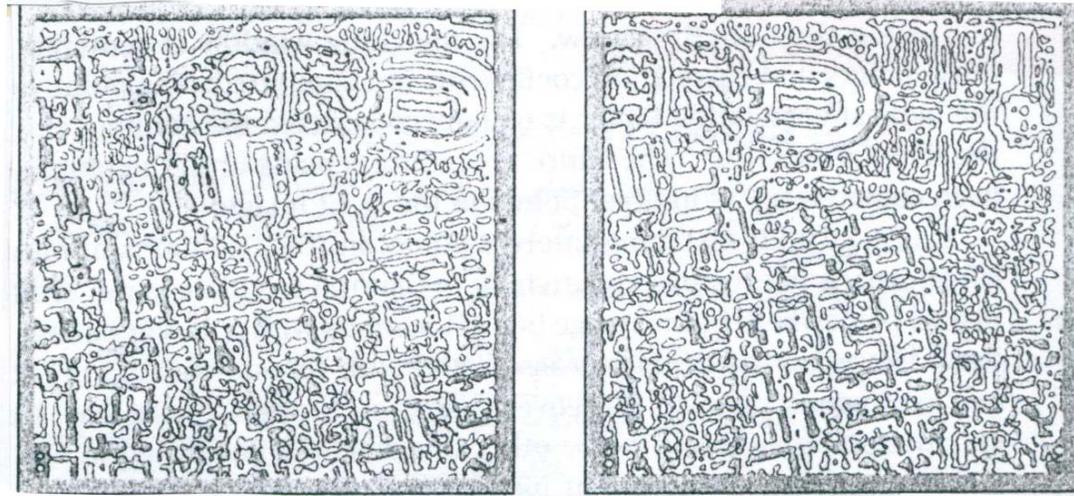
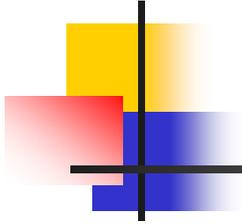
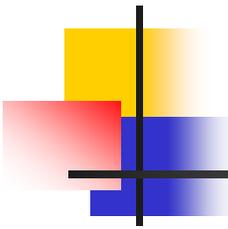


Figure 3.5: Laplacian of Gaussian (LoG) Mask Filter

Matching Edge Pixels

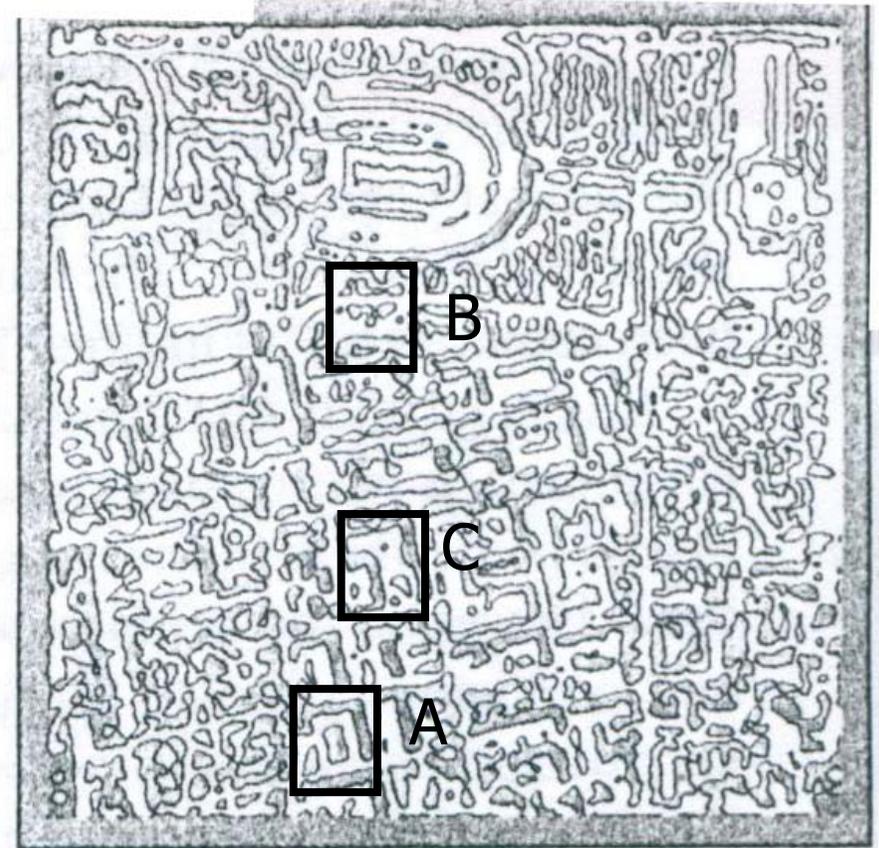
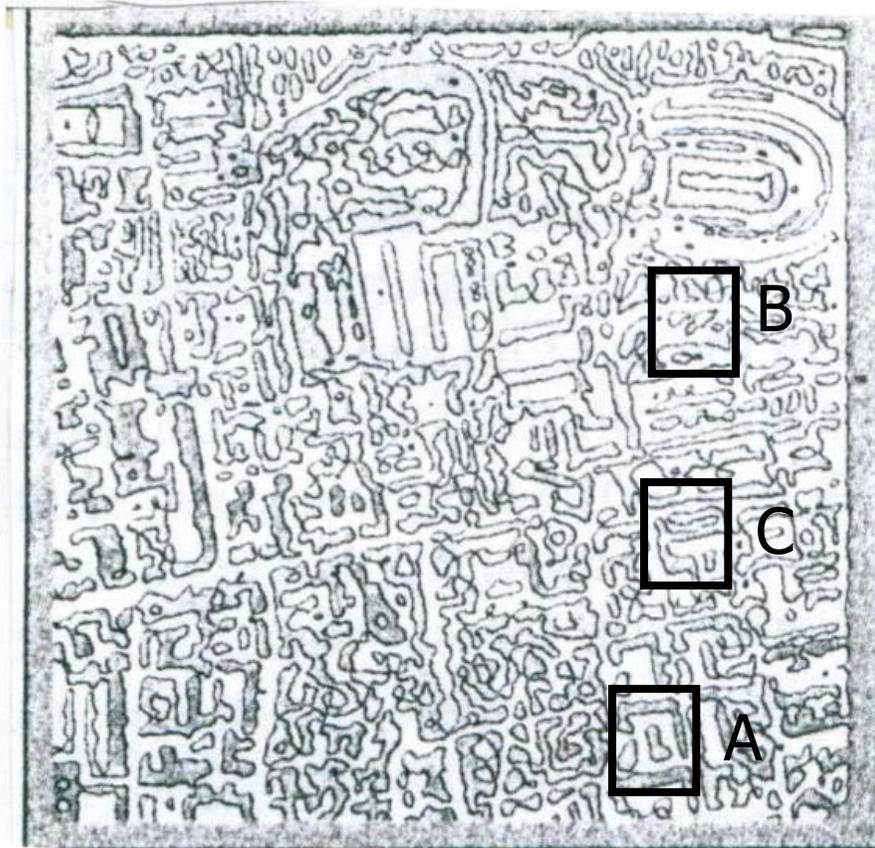
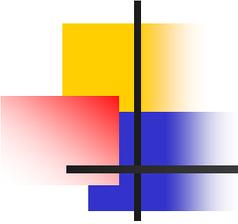


Matching Entire Edges

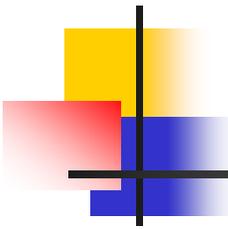


- Matching entity is an entire edge rather than individual pixels
- Suitable for relative orientation
- Depends on suitable representation of the shape characteristics of edges
- Steps:
 - extraction
 - Representation
 - Shape comparison
- Approaches
 - Ψ -S curve
 - Generalized Hough transform

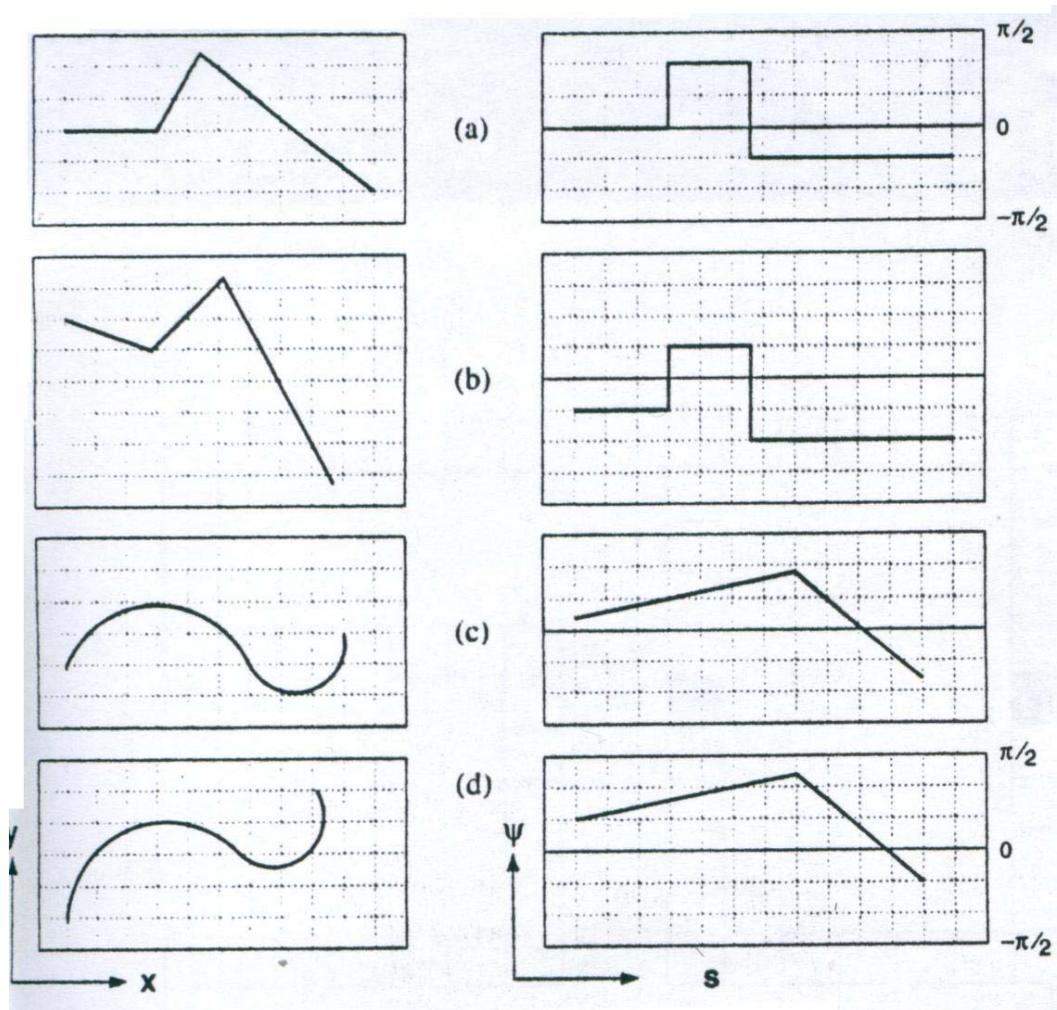
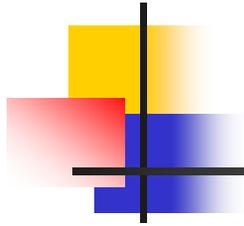
Matching Entire Edges



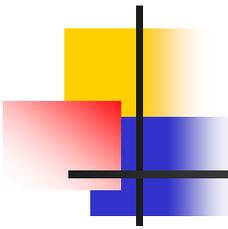
Ψ -S Approach

- 
- Representation of a line where the arc length S is the parameter of tangent Ψ
 - straight line in spatial domain correspond to horizontal straight line in Ψ - S domain
 - Advantages:
 - Invariant wrt to edge's position in the image
 - Edges are represented as a sequence of edge pixels, chain codes
 - Possible to extract distinct shape features

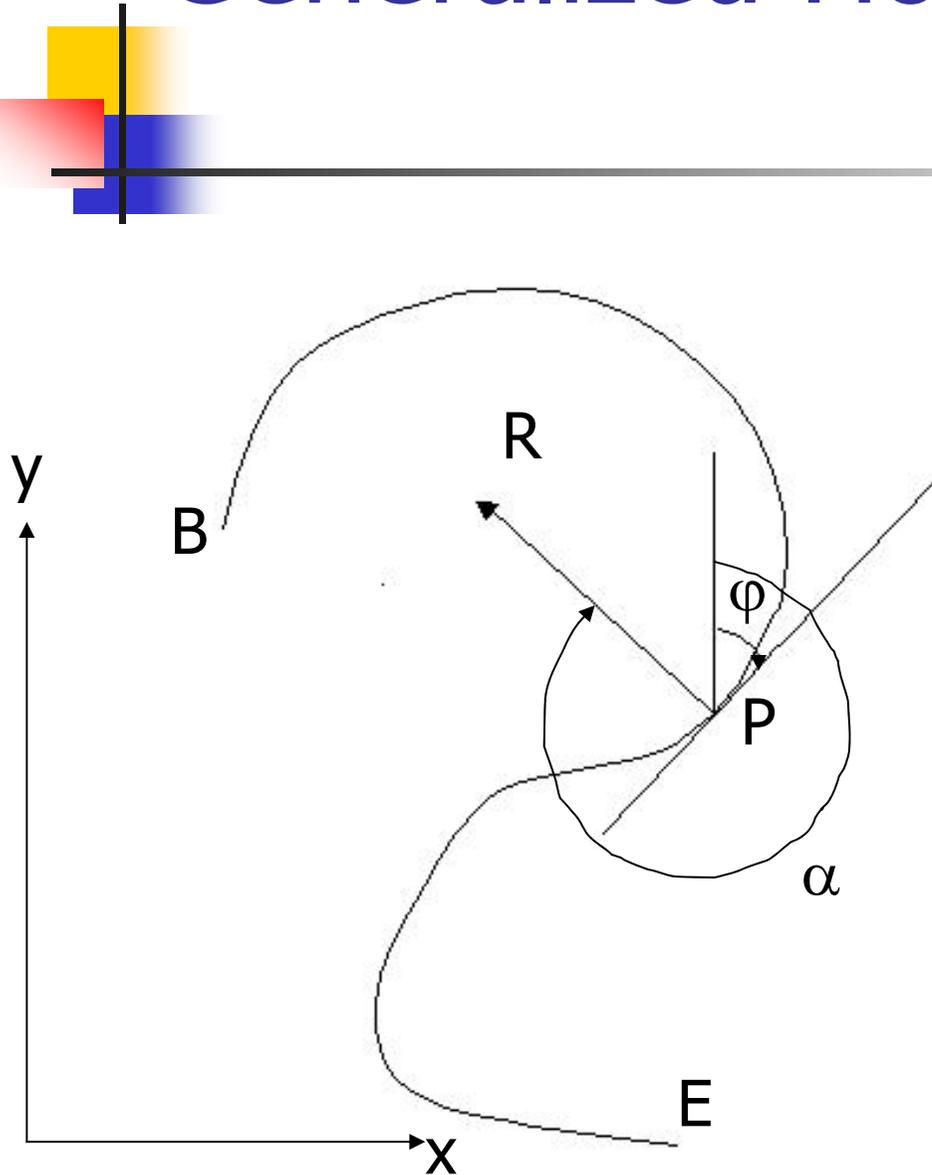
Ψ -S Approach



Ψ -S Approach

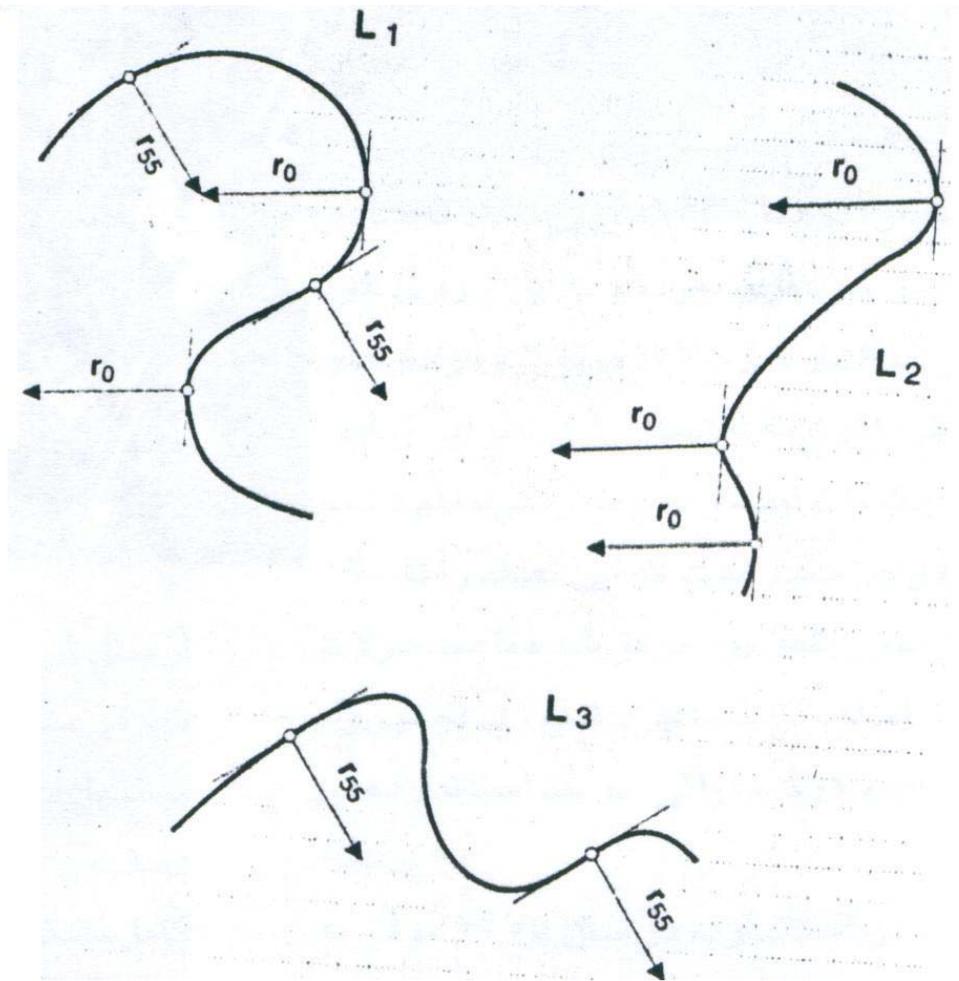
- 
- To segment the Ψ -S curve into a sequence of straight lines
 - To extract shape features by analyzing the segmented Ψ -S curve
 - To find similar vertices
 - To check local and global consistency

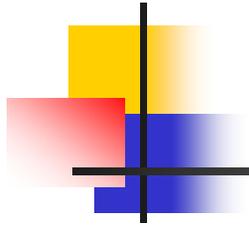
Generalized Hough Transform



Pixel	Tangent	Polar Coordinates	
		r(mm)	α
B	20	46	100
1	21	45	103
.	.	.	.
P	43	39	301
.	.	.	.
E	28	85	338

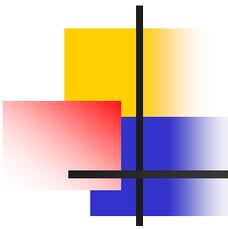
Generalized Hough Transform





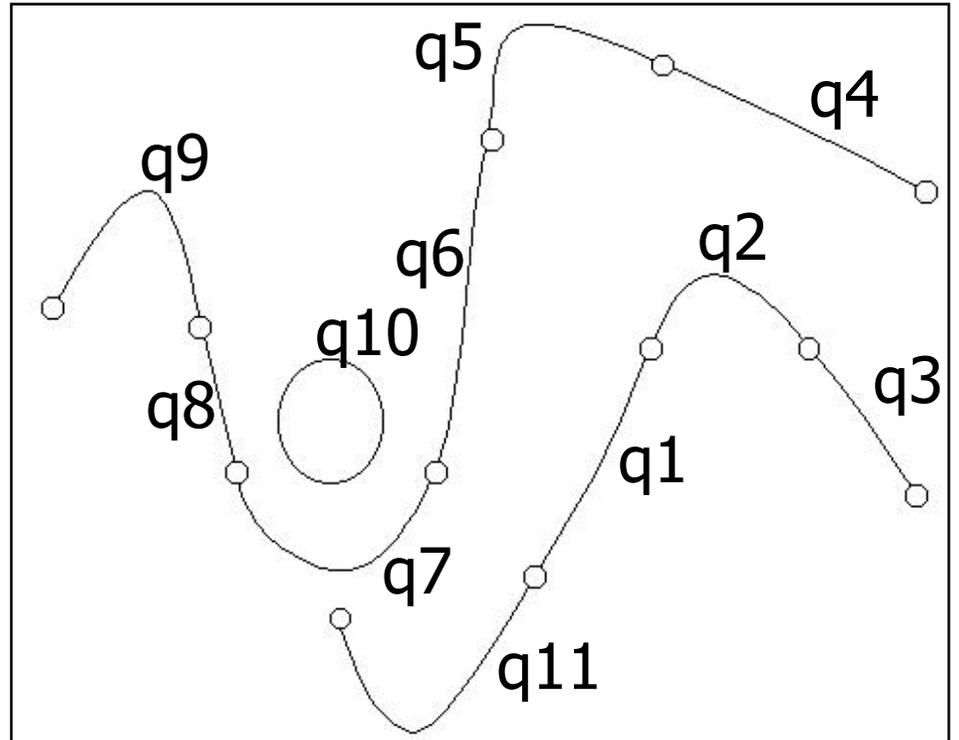
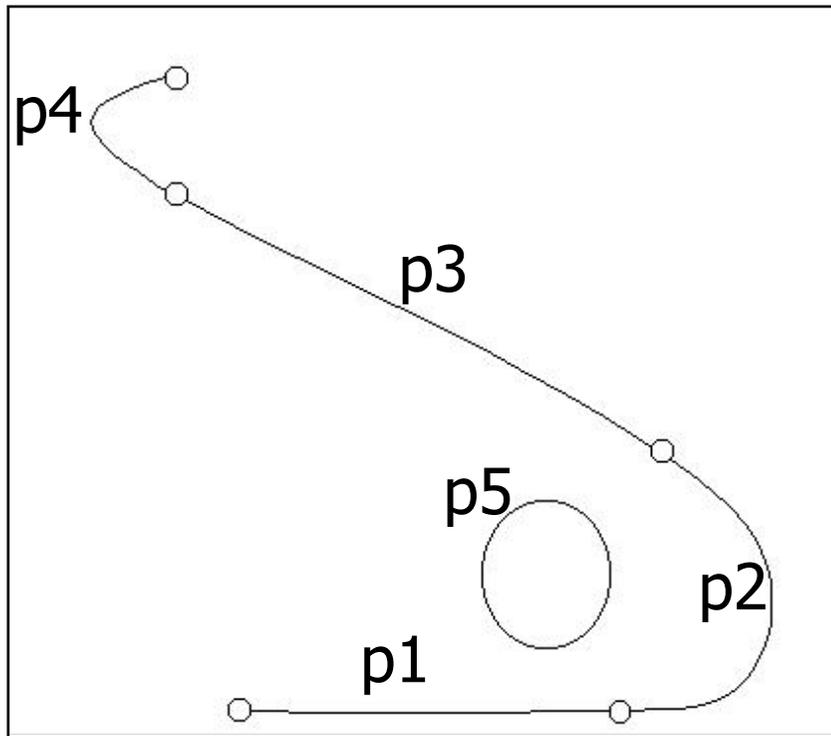
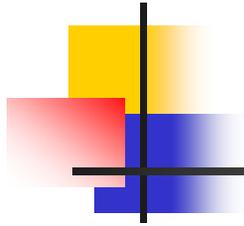
Relational Matching

Description of Primitives Relations

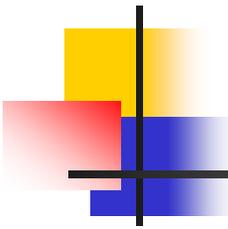


$$p_i = \{Centroid(x_i, y_i), Length(l_i), Curvature(c_i), arc(\alpha_i)\}$$

Description of Primitives and Relations



Description of Primitives and Relations

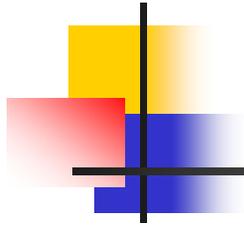


(Connection) $\{p_2p_1\}, \{p_3p_2\}, \{p_4p_3\}$

(Neighbor) $\{p_5p_1\}, \{p_5p_2\}, \{p_5p_3\}$

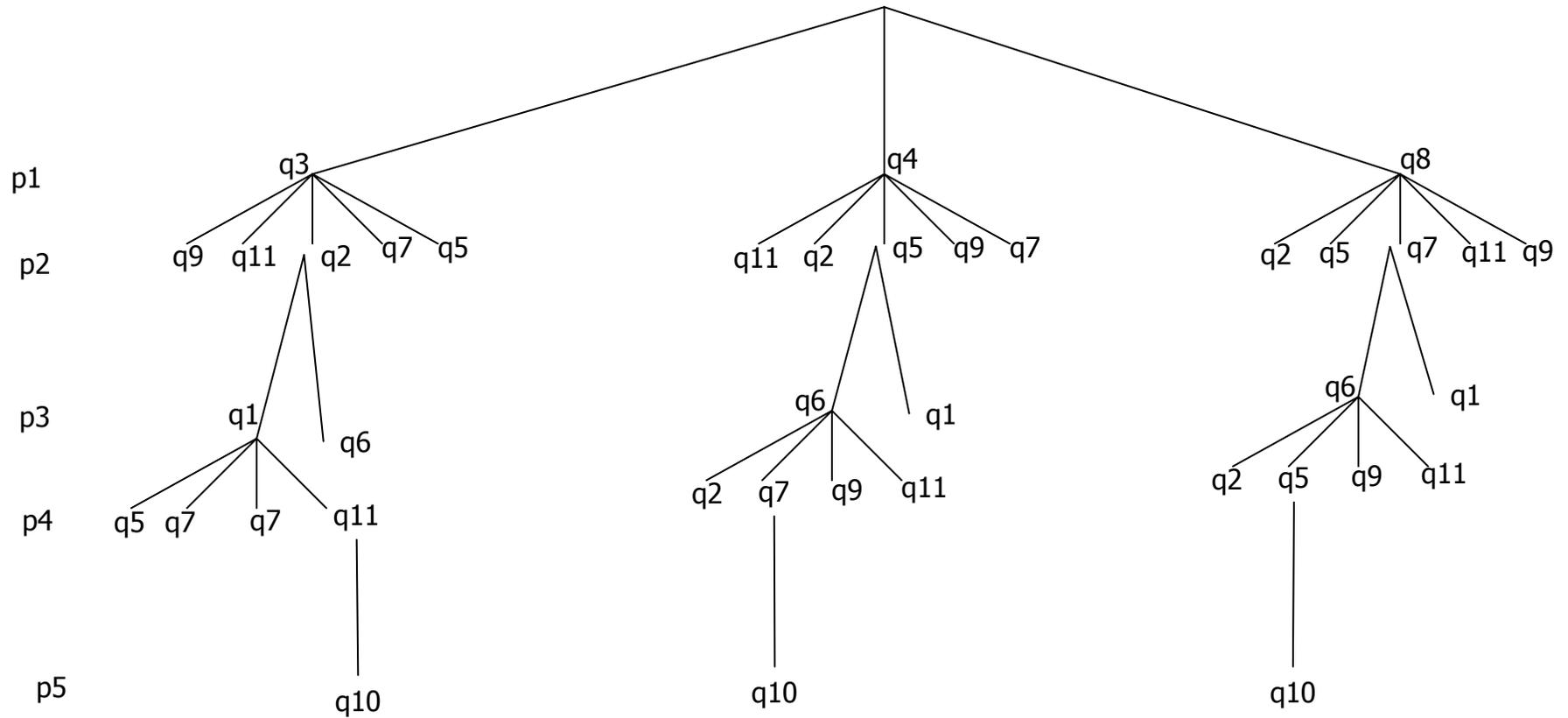
(Neighbor) $\{p_5p_2\}$ (*distance* – 12)

$\{p_5p_1\}$ (*distance* – 18)

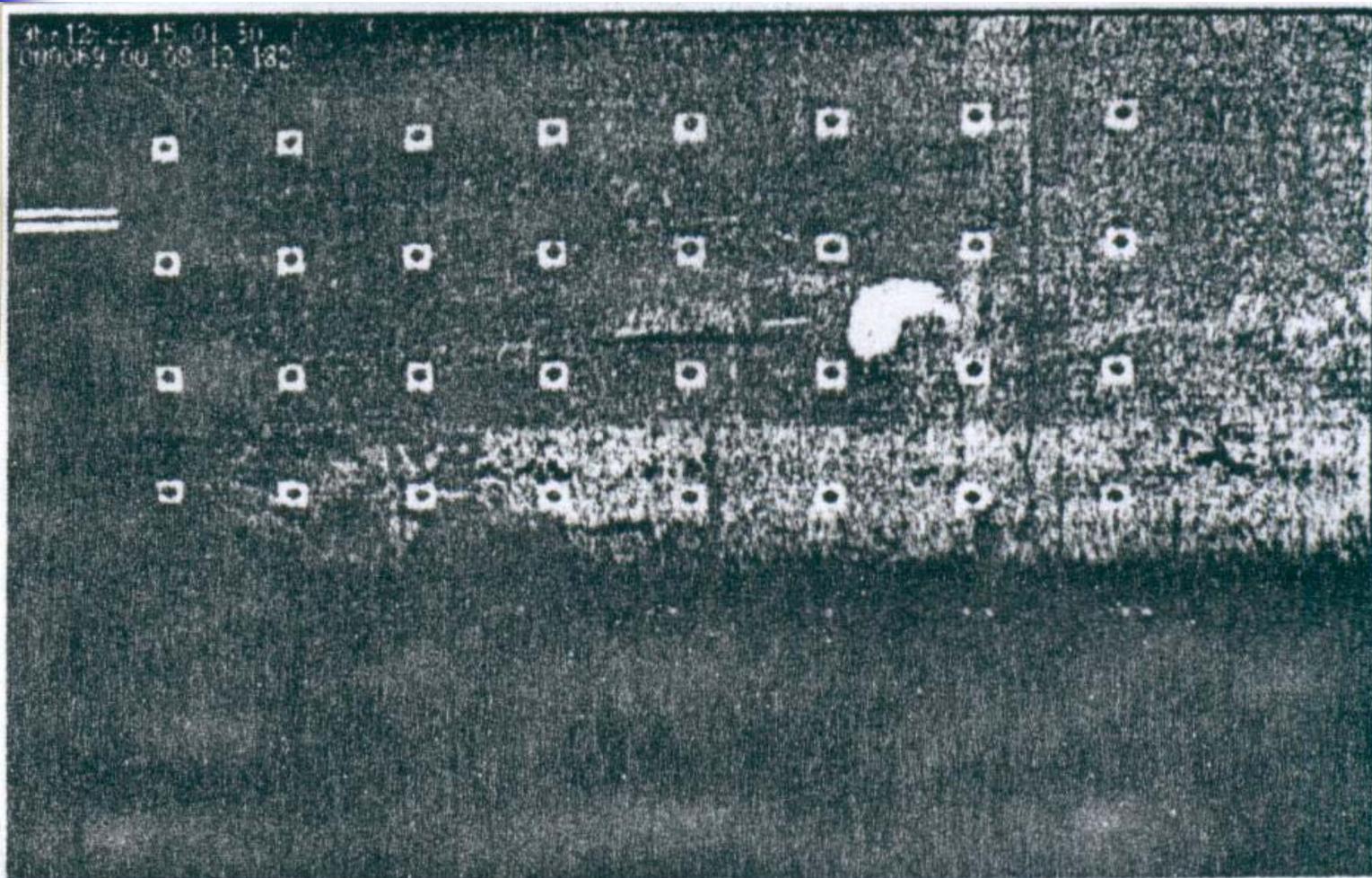


Evaluation Function

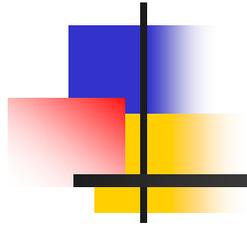
Tree Search



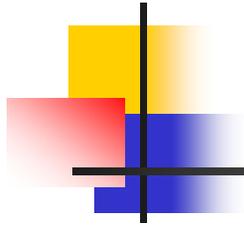
Template Matching



Matching Environment

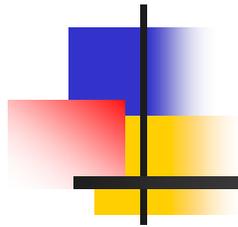


- Illumination
- Object Space
- Image Space



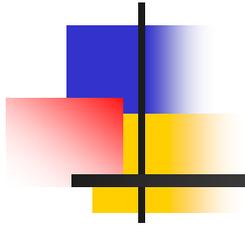
Matching Strategy

Target Detection

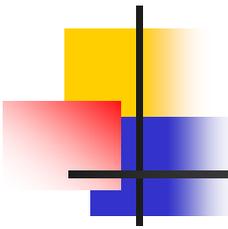


- Computational Approach
- Histogram Thresholding
- Cross-Correlation
- Feature-Based Matching

Precise Localization



- Area-Based Methods
- Feature-Based Methods

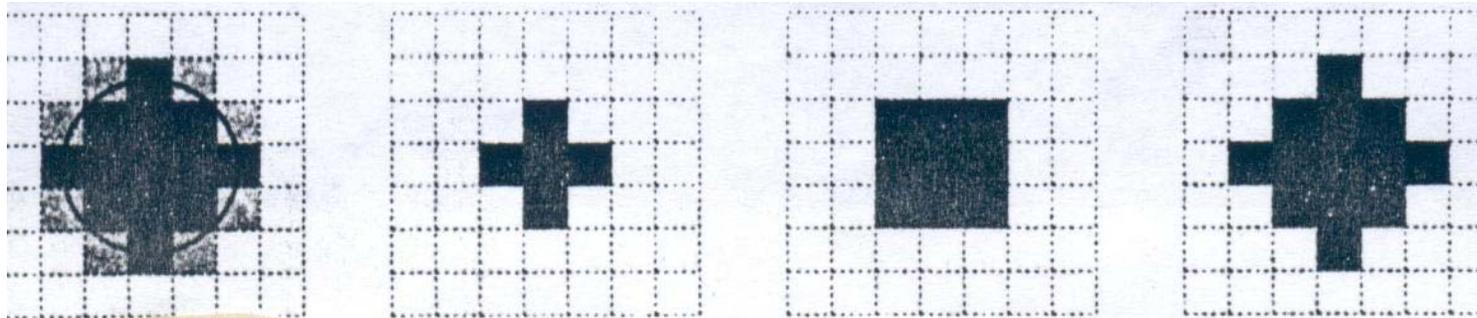


Area-Based Methods

$$m_r = \frac{1}{m_0} \sum_{i=1}^N \sum_{j=1}^M f(i, j) j$$

$$m_c = \frac{1}{m_0} \sum_{i=1}^N \sum_{j=1}^M f(i, j) i$$

Area-Based Methods

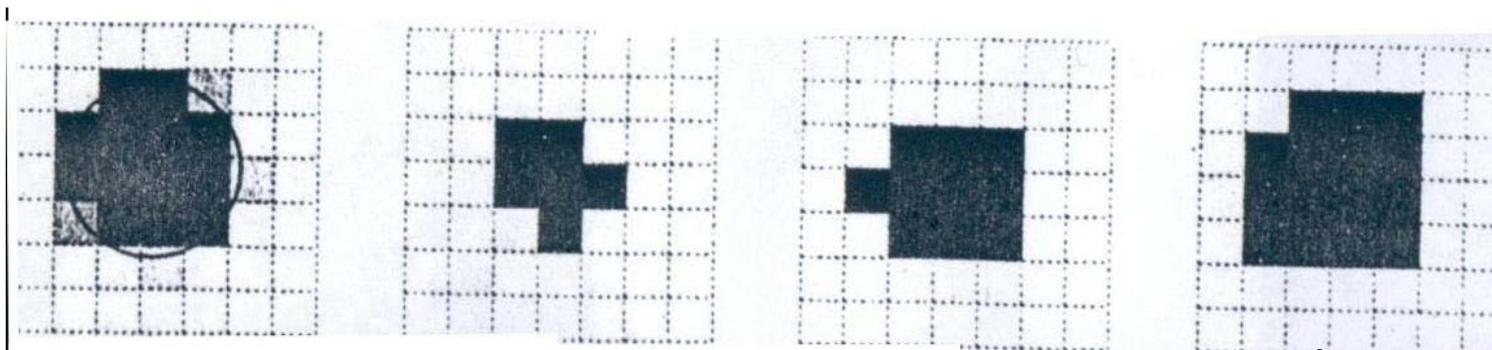


a

b

c

d



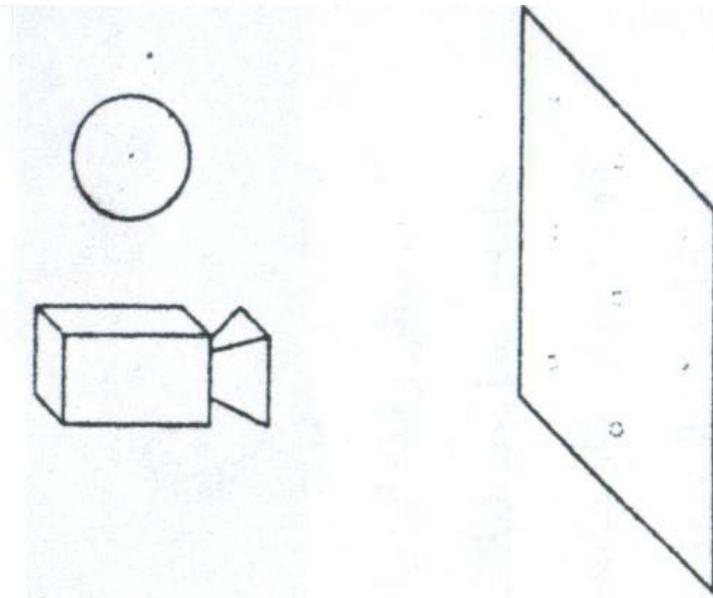
a

b

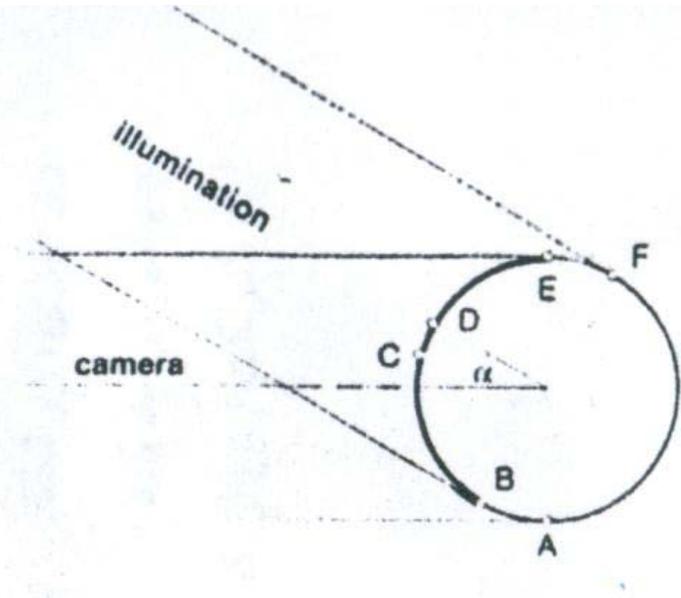
c

d

Area-Based Methods

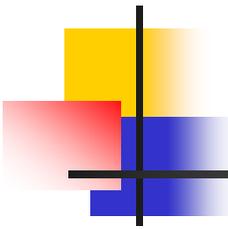


a



b

References



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- M. Kasser and W. Egels, “ Digital Photogrammetry”, Taylor and Francis, 2002
- H. Ebadi, “ Advanced Analytical Aerial Triangulation”, Lecture Note, K.N.Toosi University of Technology, 1999
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