Recapitulation

- What is pixel neighborhood and different types of neighborhood
- Explain what is meant by connectivity
- Explain what is adjacency and different type of adjacency
- Learn connected component labeling algorithm

Relationships between pixels

➢On completion the students will be able to

1. Learn different distance measures
2. Application of Distance measure
3. Arithmetic/ Logical operations on images
4. Neighborhood operations on images

Distance Measures

Take three pixels

$P \approx (x,y)$ $\quad$ $q \approx (s,t)$ $\quad$ $z \approx (u,v)$

D is a distance function or metric if

$D(p,q) \geq 0 \quad ; \quad D(p,q) = 0 \quad \text{iff} \quad p = q$

$D(p,q) = D(q,p)$

$D(p,z) \leq D(p,q) + D(q,z)$

$\times$ q
(s,t)

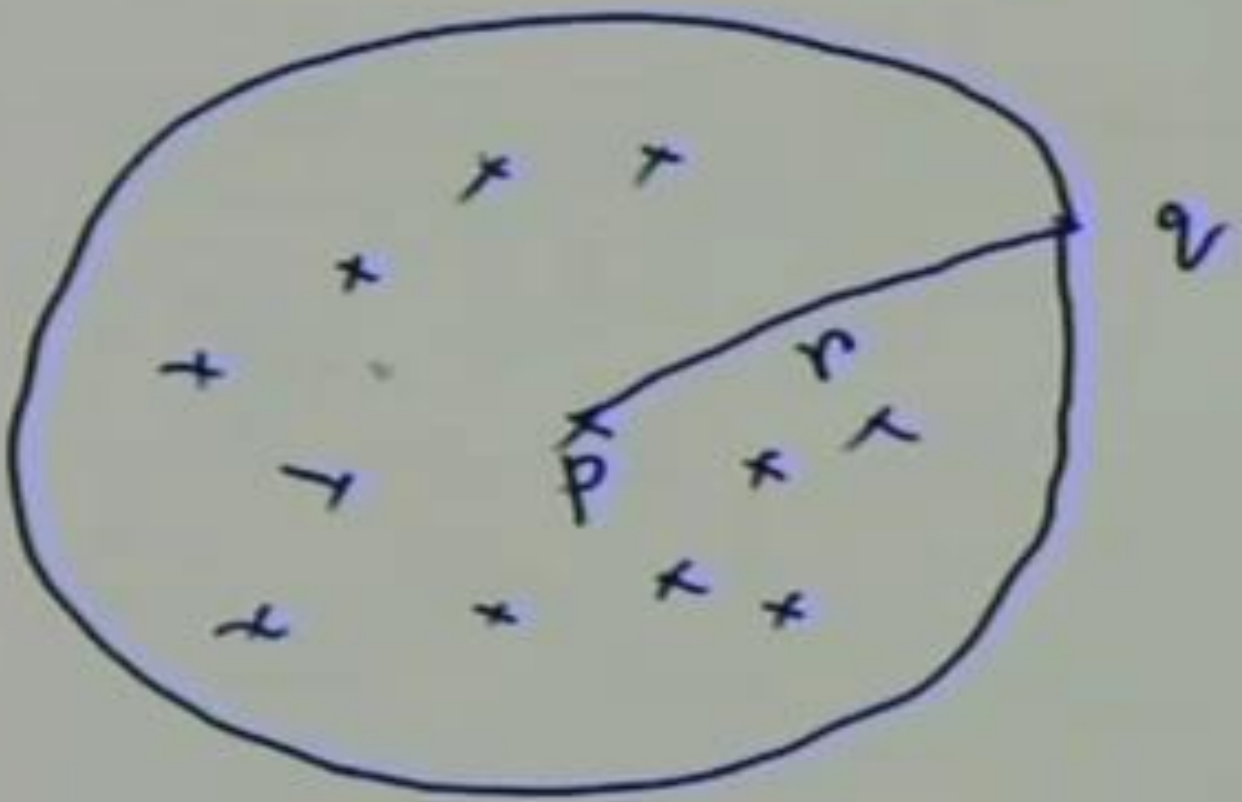
$\times$
$p(x,y)$

$$D(p,q) = \left[(x-s)^2 + (y-t)^2\right]^{1/2}$$

Euclidean Distance

$$D_e(p,q) = [\ (x-s)^2 + (y-t)^2\ ]^{1/2}$$

Set of points $S = \{\ q \mid D(p,q) \leq r\ \}$ are the points contained in a disk of radius r centered at p.



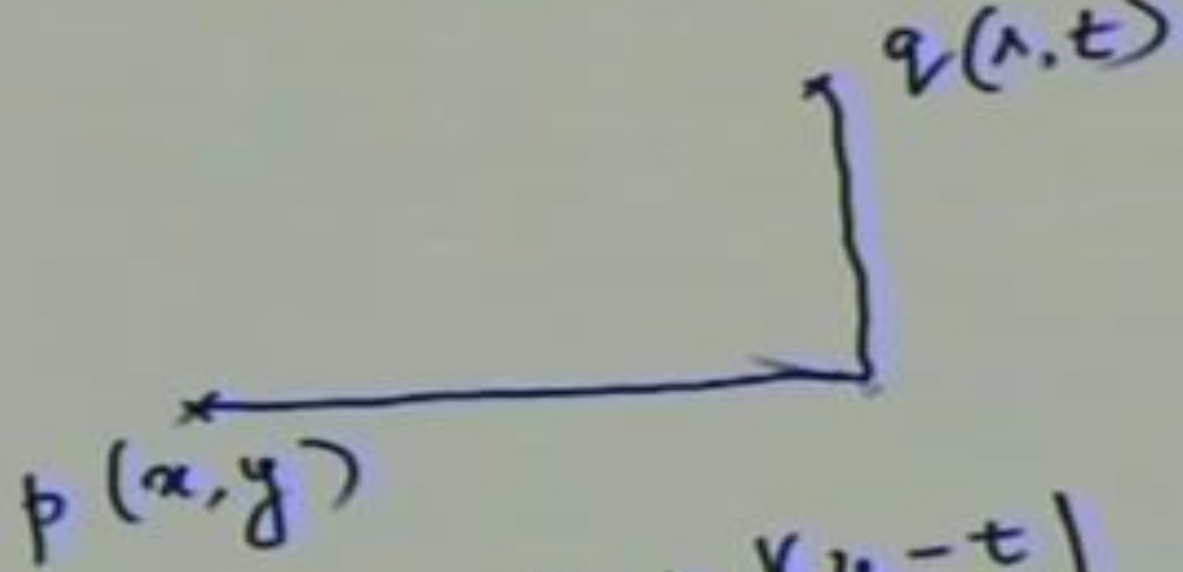
q
r
P

City-Block Distance

D_4 distance or City-Block (Manhattan) Distance.

$$D_4(p,q) = | x-s | + | y-t |$$

Points having city block distance from p less than or equal to r from diamond centered at p.



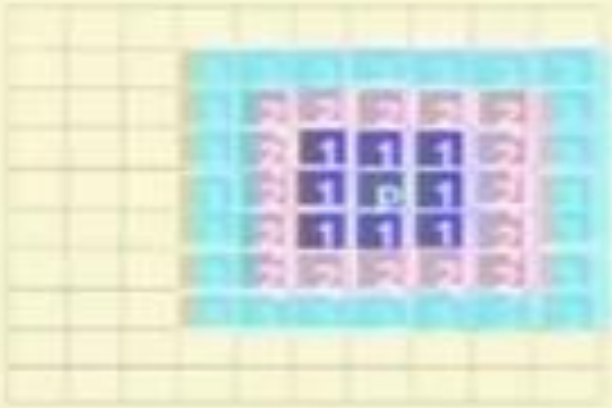
$$D_4 = |x - s| + |y - t|$$

Chess Board Distance

D_8 distance or chess board distance is defined as

$$D_8(p,q) = \max(|x-s|, |y-t|)$$

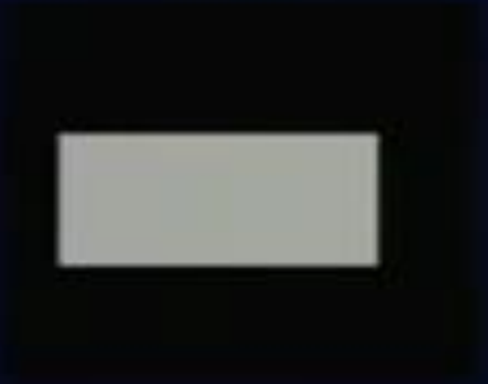
$S = \{ q \mid D_8(p,q) \leq r \}$ forms a square centered at p.



Points with $D_8 = 1$ are 8 neighbors of p

Applications of Distance Measures

Shape Matching

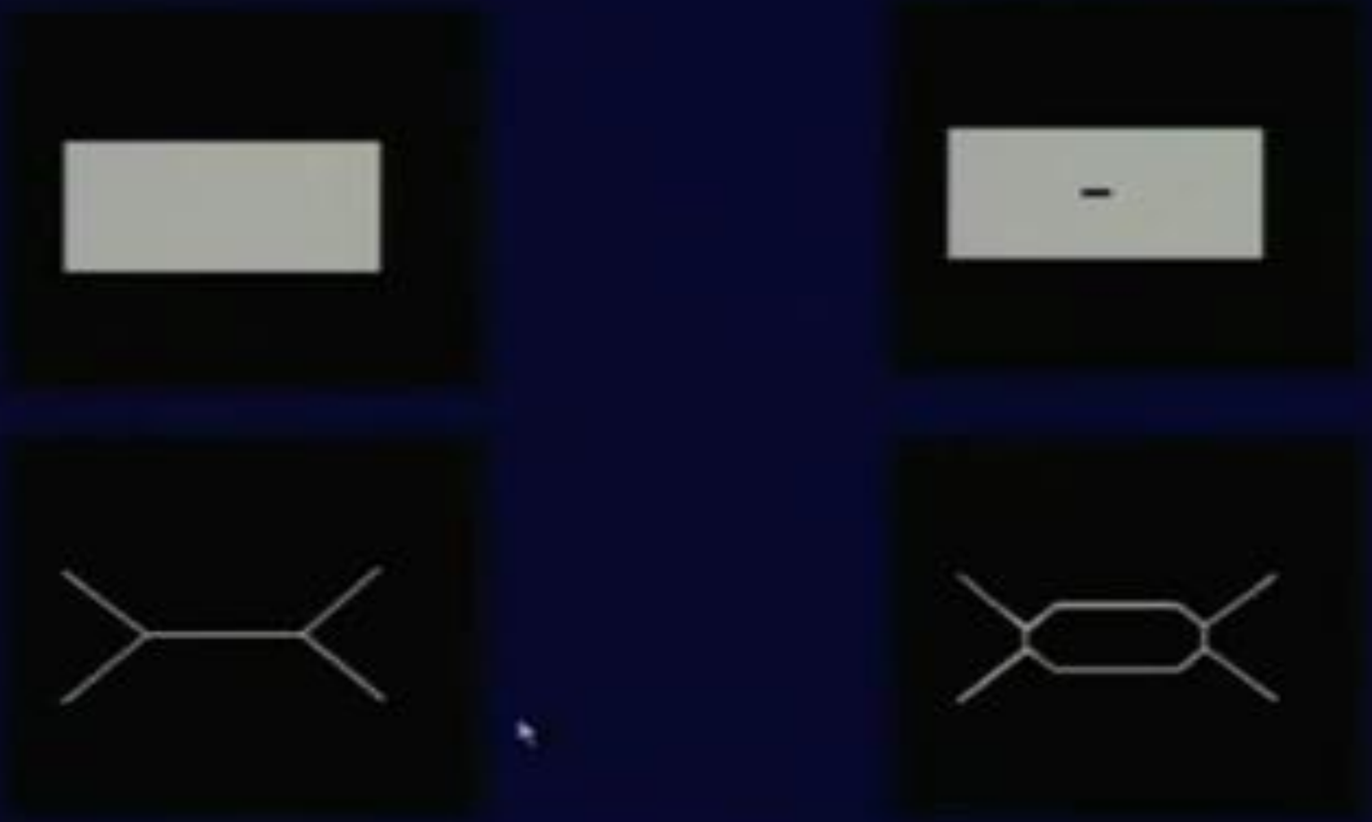


Applications of Distance Measures

Shape Matching

Applications of Distance Measures

Shape Matching



Applications of Distance Measures

Skeletonization/ Medial Axis Transformation

What is Skeletonization?

- Process for reducing foreground regions in a binary image to a skeletal remnant that largely preserves the extent and connectivity of the original region while throwing away most of the original foreground pixels

Applications of Distance Measures

Skeletonization/ Medial Axis Transformation

How it works?

- Imagine that the foreground regions in the input binary image are made of some uniform slow-burning material
- Light fires simultaneously at all points along the boundary of this region and watch the fire move into the interior
- At points where the fire traveling from two different boundaries meets itself, the fire will extinguish itself and the points at which this happens form the so called `quench line'
- This line is the skeleton

Applications of Distance Measures

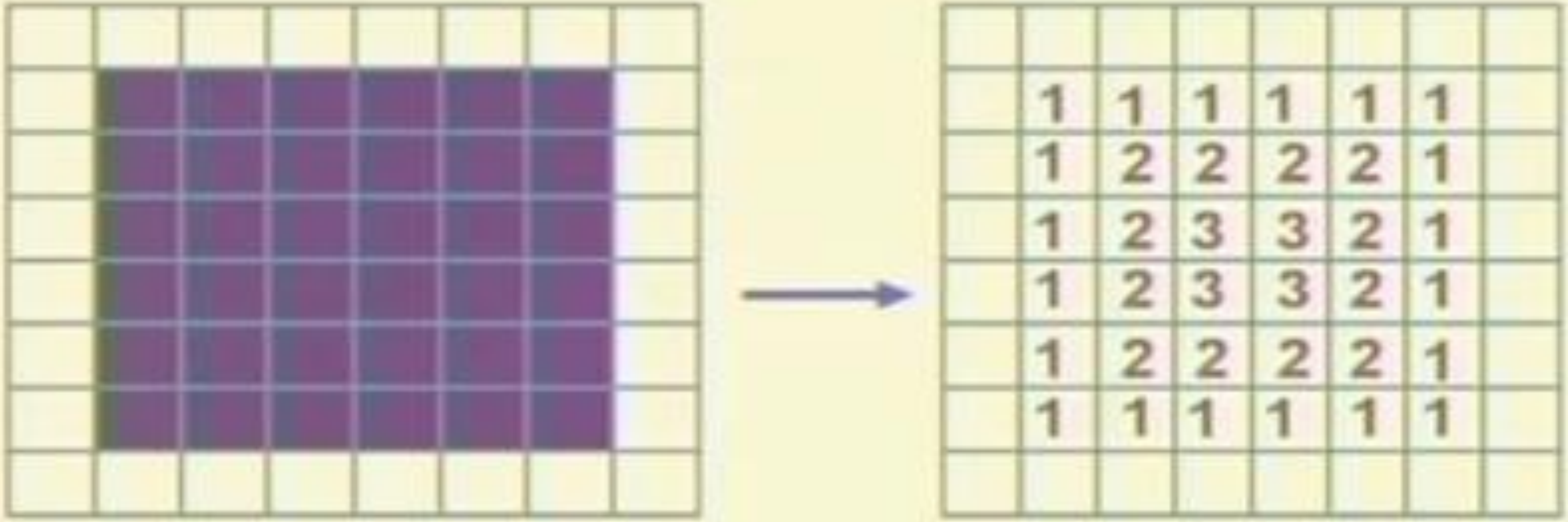
Skeletonization through Distance Transformation

What is Distance Transformation?

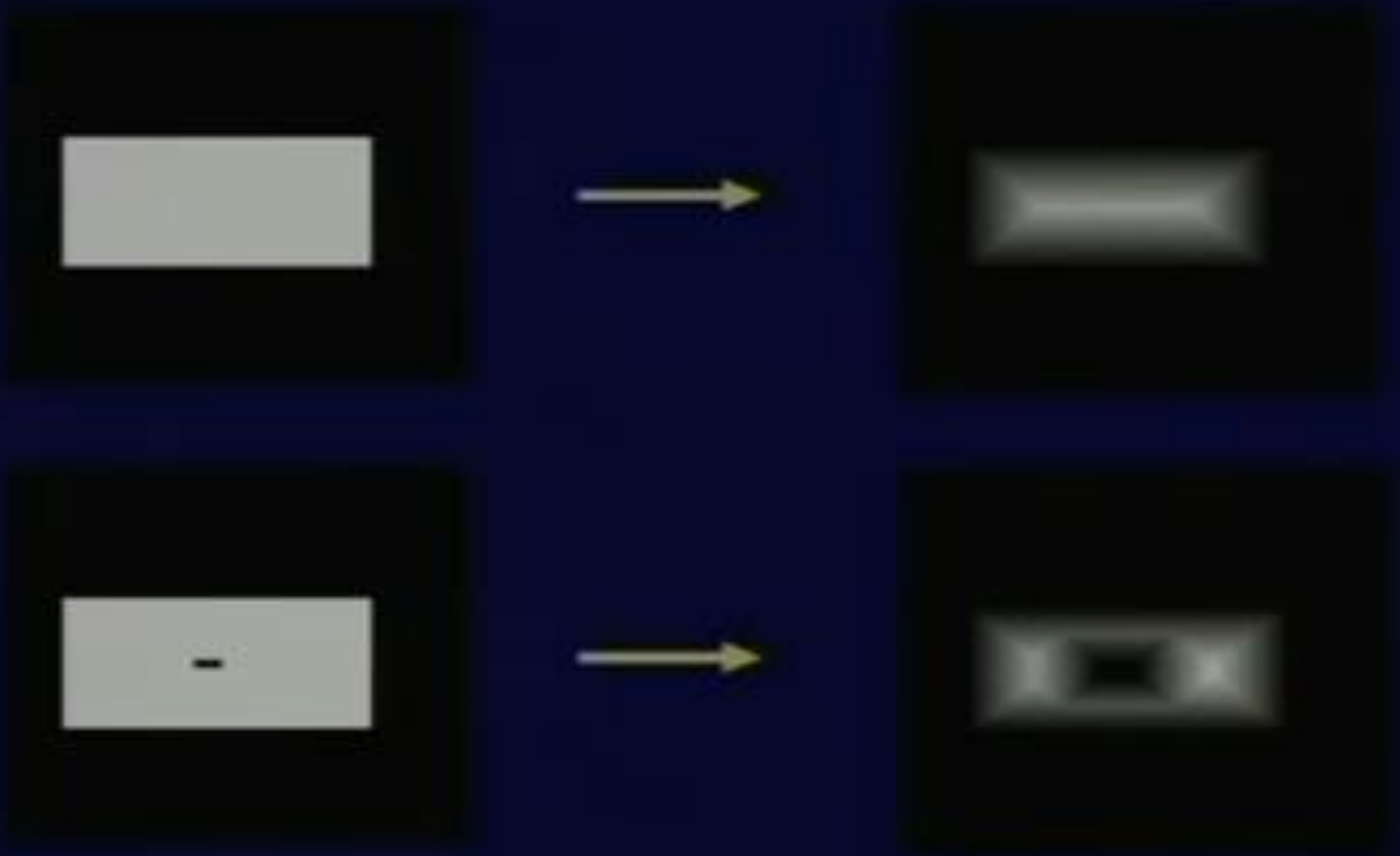
- The distance transform is an operator normally only applied to binary images
- The result of the transform is a grey level image that looks similar to the input image except that the grey level intensity of points inside foreground regions are changed to show the distance to the closest boundary from each point

Applications of Distance Measures

Distance Transform

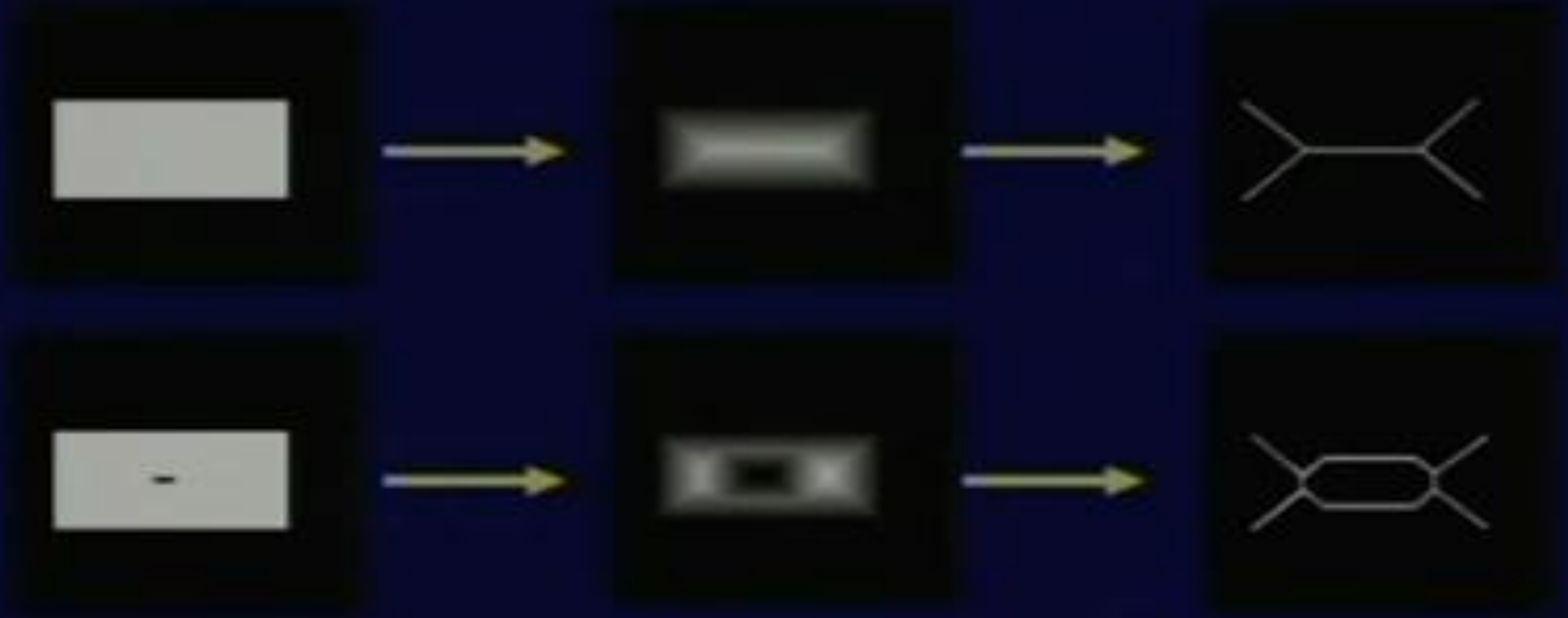


Applications of Distance Measures



Applications of Distance Measures

The skeleton lies along the *singularities* (*i.e.* creases or curvature discontinuities) in the distance transform



Applications of Distance Measures

- Just as there are many different types of distance transform there are many types of skeletonization algorithms all of which produce slightly different results. However, the general effects are all similar.
- The skeleton is useful because it provides a simple and compact representation of a shape that preserves many of the topological and size characteristics of the original shape.

Applications of Distance Measures

- Thus, for instance, we can get a rough idea of the length of a shape by considering just the end points of the skeleton and finding the maximally separated pair of end points on the skeleton.
- We can distinguish many qualitatively different shapes from one another on the basis of how many `triple points' there are *i.e.* points where at least three branches of the skeleton meet.

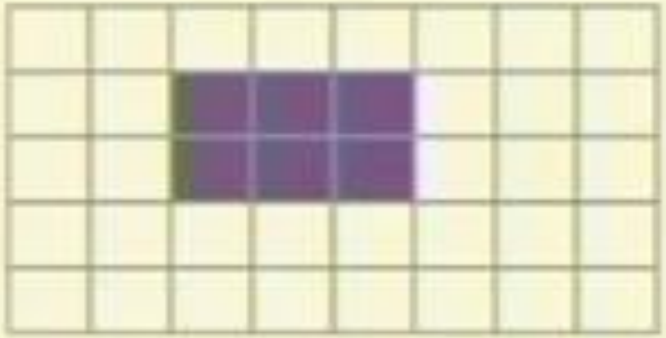
Arithmetic / Logical Operation

Following Arithmetic/Logical operations between two pixels p and q are used extensively

Arithmetic	Logical
p+q	p.q
p-q	p+q
p*q	p'
p%q	

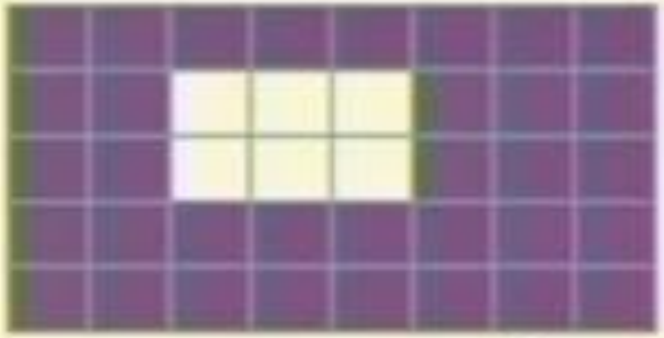
Logical operations apply to binary images Only => Usually pixel by

Arithmetic / Logical Operation

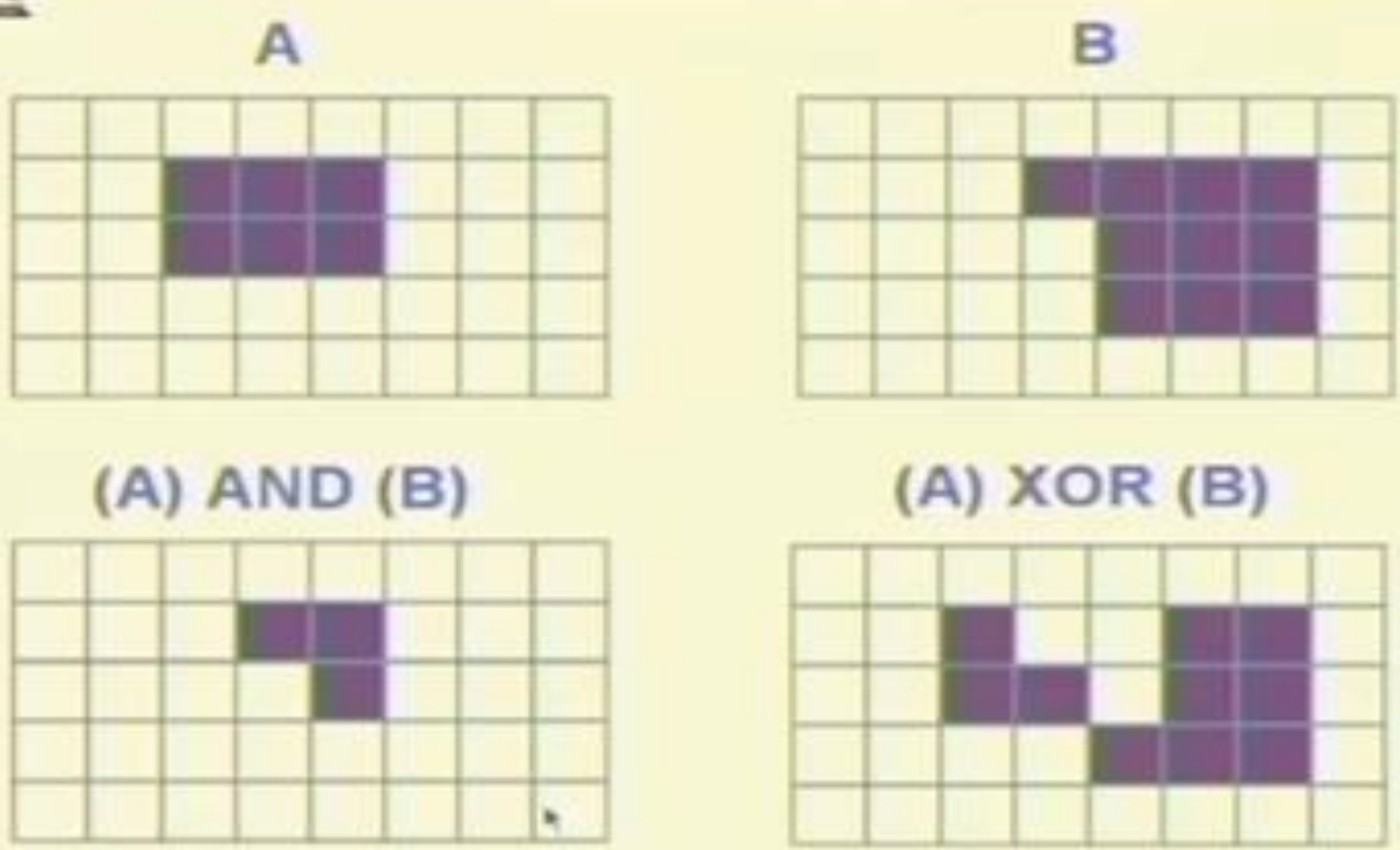


A

NOT (A)



Arithmetic / Logical Operation



Neighborhood Operations

The value assigned to a pixel is a function of its gray label and the gray labels of its neighbors.

Z_1	Z_2	Z_3
Z_4	Z_5	Z_6
Z_7	Z_8	Z_9

$Z = 1/9\ (Z_1+Z_2+Z_3+\ldots\ldots+Z_9) = \text{Average}$

Template

More general form

Z_1	Z_2	Z_3
Z_4	Z_5	Z_6
Z_7	Z_8	Z_9

W_1	W_2	W_3
W_4	W_5	W_6
W_7	W_8	W_9

$$Z = W_1Z_1 + W_2Z_2 + \dots\dots\dots + W_9Z_9$$

$$= \sum_{i=1}^{9} W_iZ_i$$

Same as averaging if $W_i = 1/9$

Neighborhood Operations

Various important operations can be Implemented by proper selection of Coefficients W_i

----- Noise filtering

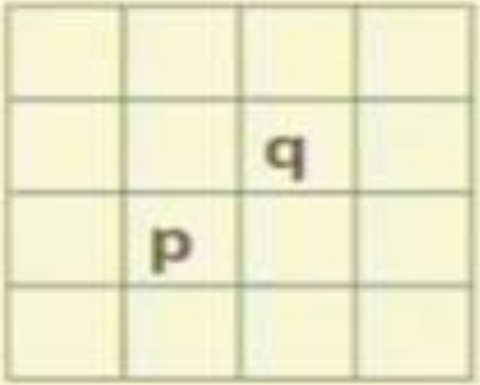
----- Thinning

----- Edge detection

etc…

Quiz Questions on Lecture 4 & 5

1. In the following figure which of the options are true?
   a. $q \in N_4(p)$
   b. $q \in N_8(p)$
   c. $q \in N_D(p)$



2. Find out
   a. Euclidean
   b. City block
   c. Chess board

   distances between

   p and q in the above figure