Relationships between pixels

- On completion the students will be able to
  1. Explain what is pixel neighborhood and different types of neighborhood
  2. Explain what is meant by connectivity
  3. Learn connected component labeling algorithm
  4. Explain what is adjacency and different type of adjacency
  5. Learn different distance measures

Neighborhoods of a pixel

- A pixel p at location (x,y) has ~~four~~ two horizontal
  And ~~four~~ two vertical neighbors.

	(x-1,y)	
(x,y-1)	p (x,y)	(x,y+1)
	(x+1,y)	

- This set of four pixels is called 4-neighbors Of $p = N_4(p)$.
- Each of these neighbors is at a unit distance From p.
- If p is a boundary pixel then it will have less Number of neighbors.

Diagonal & 8-neighbors.

A pixel p has four diagonal neighbors=$N_D(p)$

(x-1,y-1)		(x-1,y+1)
	p (x,y)	
(x+1,y-1)		(x+1,y+1)

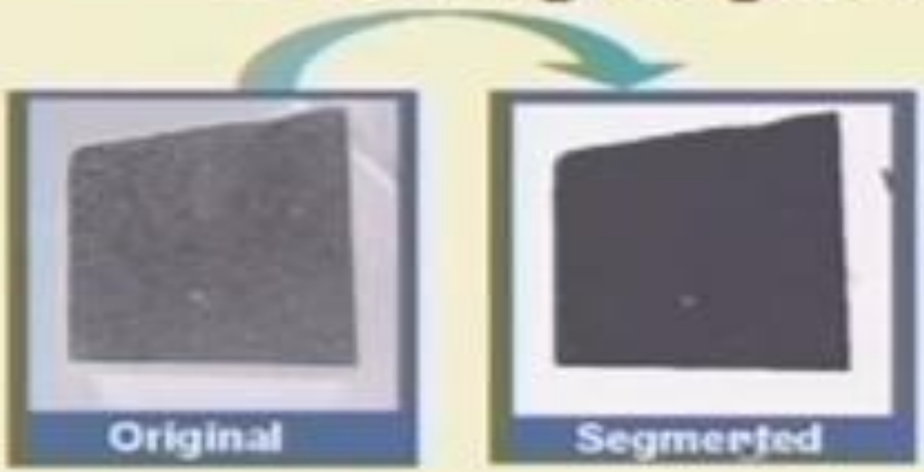
The points of $N_4(p)$ and $N_D(p)$ together are
Called 8-neighbors of p.
$N_8(p) = N_4(p) \cup N_D(p)$

If p is a boundary pixel then both $N_D(p)$ and
And $N_8(p)$ will have less number of pixels.

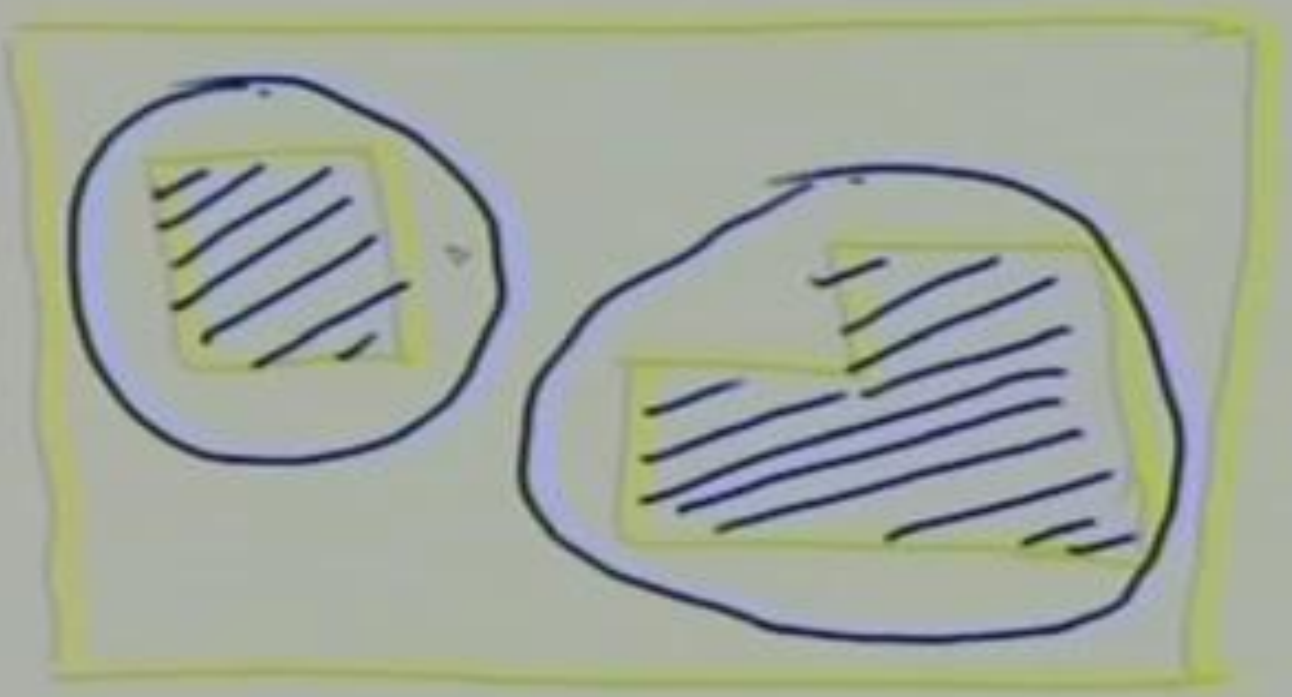
Connectivity

Connectivity between pixels is a very important concept.

It is very useful for
-- Establishing object boundaries
-- Defining image components/regions etc



If $F(x,y) > Th$
$\Rightarrow (x,y) \in$ Object
Else
$(x,y) \in$ background



What is connectivity ?

Two pixels are said to be connected if they are adjacent in some sense

-- They are neighbors(N_4,N_D or N_8) and

-- Their intensity values (gray levels) are similar

Ex: For a binary image B, two points p and q Will be connected if $q \in N(p)$ or $p \in N(q)$ and $B(p) = B(q)$.

	q	
	p	

		q
	p	

	p	q

.....etc

Connectivity

Let V be the set of gray levels used to define Connectivity for two points $p,q \in v$, three types of Connectivity are defined

- 4-connectivity=>$p,q \in v$ & $p \in N_4(q)$
- 8-connectivity=>$p,q \in v$ & $p \in N_8(q)$
- M-connectivity (mixed connectivity)

  $p,q \in v$ are m-connected if

  (i) $q \in N_4(p)$ Or

  (ii) $q \in N_D(p)$ and $N_4(p) \cap N_4(q) = \phi$

should not have a common neighbour

$N_4(p) \cap N_4(q)$ => set of pixels that are 4-neighbors Of both p and q and whose values are from v.

Connectivity

Mixed connectivity is a modification of 8-connectivity

-- Eliminates multiple path connections that often arise with 8-connectivity.

Ex: $V = \{1\}$

0	1	1
0	1	0
0		1

4 - connected

0	1	1
0	1	0
0	0	1

8 - connected

0	1	1
0	1	0
0		1

m - connected

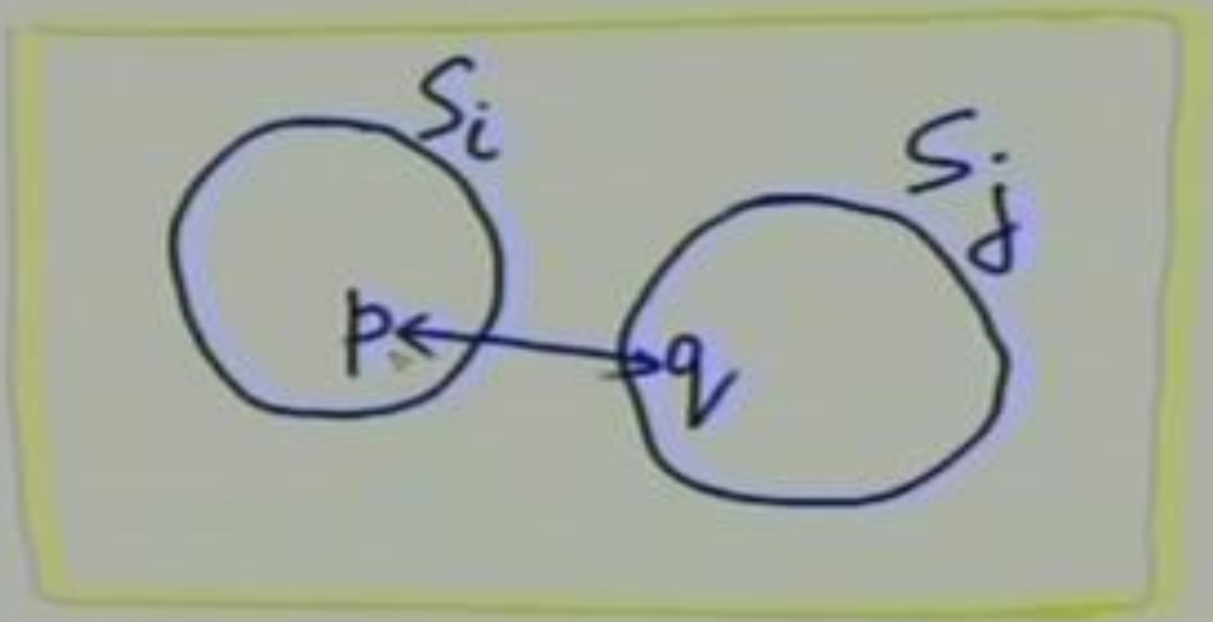
Adjacency

Two pixels p and q are adjacent if they are connected

- 4-adjacency
- 8-adjacency
- m-adjacency

-- depending on type of connectivity used.

Two image subsets S_i and S_j are adjacent if $\exists\ P \in S_i$ and $\exists\ q \in S_j$ such that p and q are adjacent



S_i
S_j
p
q

Path

A path from $p(x,y)$ to $q(s,t)$ is a sequence of distinct pixels.

(x_0,y_0), (x_1,y_1).........(x_n,y_n)

Where

q

$(x_0,y_0) = (x,y)$, $(x_n,y_n) = (s,t)$
(x_i,y_i) is adjacent to (x_{i-1},y_{j-1})
for $1 \leq i \leq n$

$n \Rightarrow$ length of the path.

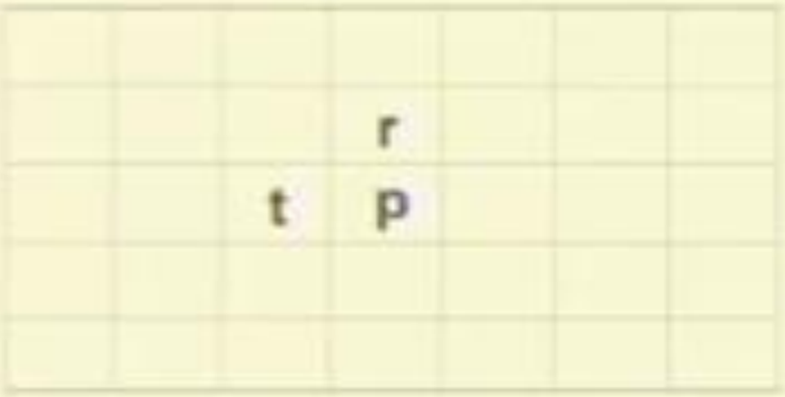
Connected component labeling

Ability to assign different labels to various disjoint connected components of an Image.

Connected component labeling is a fundamental step in automated image analysis
-Shape
-Area
-Boundary
-Shape/Area/Boundary based features

Algorithm

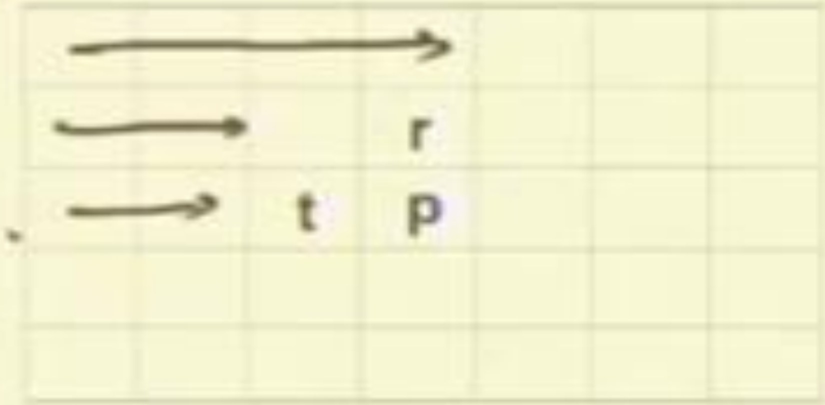
Scan an image from left to right and from top to bottom.
Assume 4 - connectivity
P be a pixel at any step in the scanning process.



Before p, points r and t are scanned

Algorithm

Scan an image from left to right and from top to bottom.
Assume 4 - connectivity
P be a pixel at any step in the scanning process.



Before p, points r and t are scanned

Steps

I(p) => Pixel value at position p.

L(p) => Label assigned to pixel location p.

If I(p) = 0, move to next scanning position.

If I(p) = 1 and I(r) = I(t) = 0

Then assign a new label to position p

If I(p) = 1 and only one of the two neighbor is 1

Then assign its label to p.

If I(p) = 1 and both r and t are 1's, then

- If L(r) = L(t) than L(p)=L(r)
- If L(r) $\neq$ L(t) then assign on of the labels to p and make a note that the two labels are equivalent

Connected component labeling

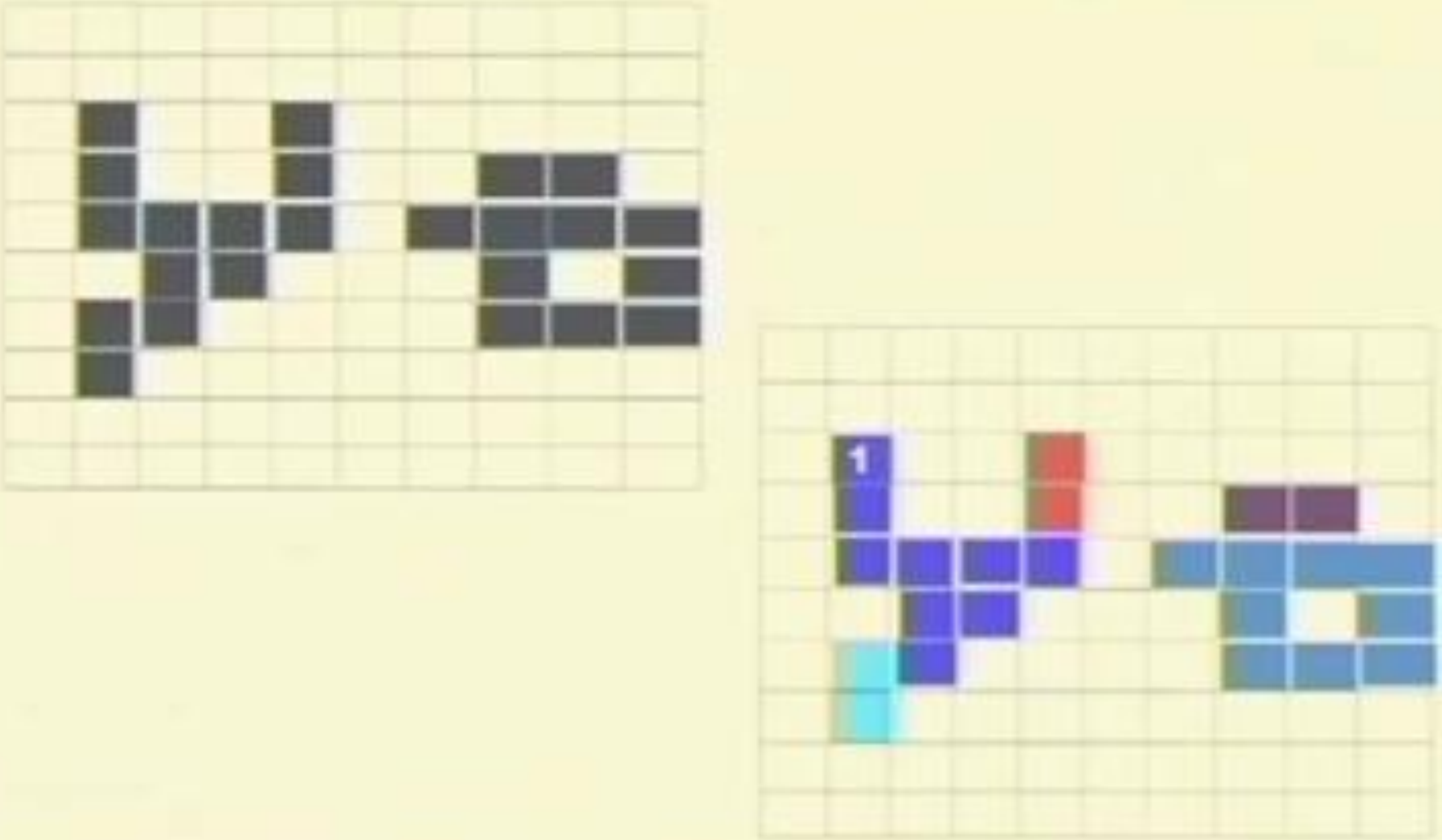
At end of the scan all pixels with value 1 are labeled.

Some labels are equivalent.

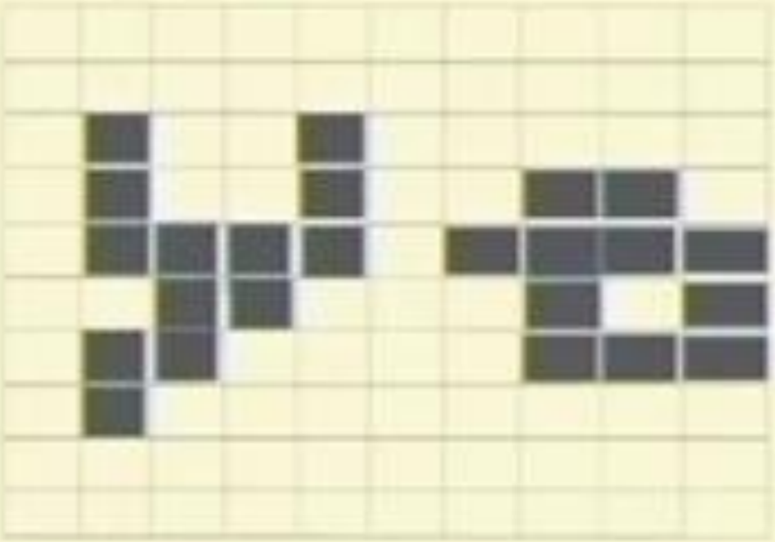
During second pass process equivalent pairs to from equivalence classes.

Assign a different label to each class. In the second pass through the image replace each label by the label assigned to its equivalence class.

Algorithm Demonstration



Algorithm Demonstration



Equivalent pairs:

(1,2) , (3,4) , (1,5)

Result

(1,2) , (1,5) = 1

(3,4) = 3