Computer Vision Module– Session 7

Computer Vision

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Online Training & Certification Course on Artificial Intelligence & Machine Learning

Defence Institute of Advanced Technology (DU), Pune.

Computer Vision

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Connectedness, object labeling and counting

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Outline of Presentation

- Introduction
- Relationships between pixels
- Adjacency
- Connectivity
- Paths and path lengths
- Distance measures
- Connected component labeling
- Object labeling and counting

Introduction

- In binary image analysis, consists of a set of image analysis operations that are used to produce or process binary images, usually images of 0's and 1's.
- 0 represents the background
- 1 represents the foreground
- Helpful in object labeling and counting

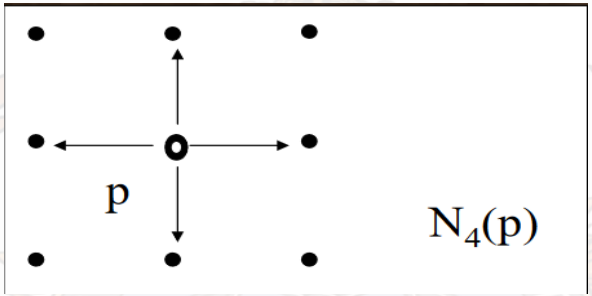
```
0001001000 1000
0001111000 1000
0001001000 1000
```

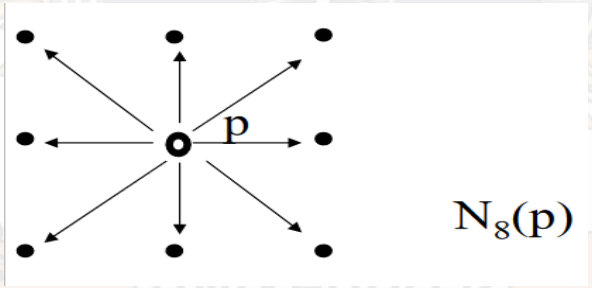
Connected Components Labeling

binary image

connected components

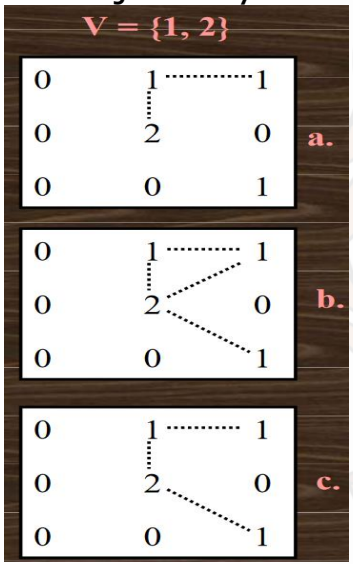
Basic Relationships Between Pixels

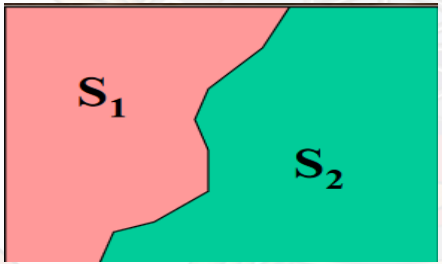




Adjacency

- Let V be set of gray levels values used to define adjacency.
- 4-adjacency
- 8-adjacency





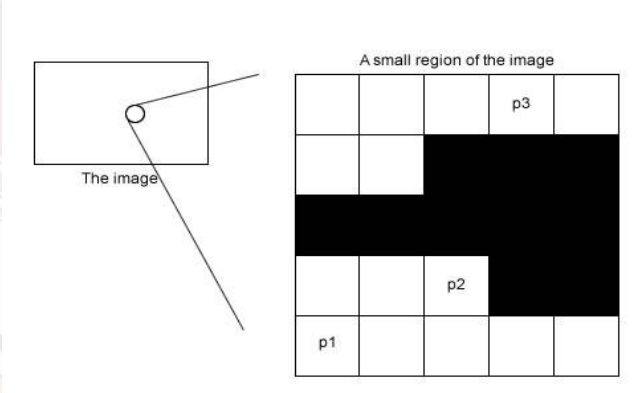
0 (a)	1 (b)	1 (c)
1 (d)	1 (p)	0 (e)
1 (f)	0 (g)	1 (h)

4 neighborhood points have 4 points b, d, e, g, but V = {1}, e and g are not equal to any element in the V set, so e and g are not adjacent to p4.
Hence 4 adjacency=> b,d

8 adjacency=> b,c,d,f,h

Connectivity

- Pixel p is adjacent to pixel q if they are connected.
- Two image subsets S1and S2 are adjacent if some pixel in S1 is adjacent to some pixel in S2



Paths & Path lengths

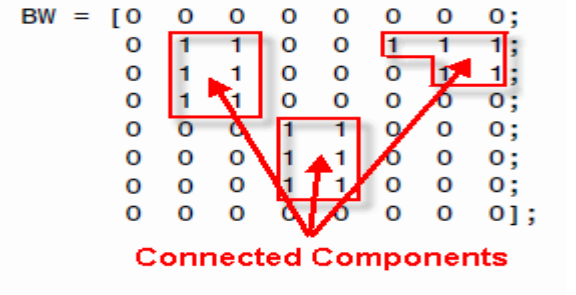
- A path from pixel p with coordinates (x, y)to pixel q with coordinates (s, t)is a sequence of distinct pixels with coordinates:
- (x0, y0), (x1, y1), (x2, y2) ... (xn, yn),
- where (x0, y0)=(x, y)and (xn, yn)=(s, t); (xi, yi) is adjacent to(xi-1, yi-1)
- Here n is the length of the path.
- We can define 4-, 8-, and m-paths based on type of adjacency used.

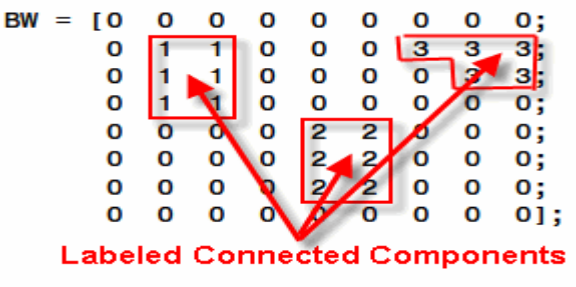
Distance Measures

- Given pixels p, q and z with coordinates (x, y), (s, t), (u, v) respectively, the distance function D has following properties:
  - a. D(p, q)=0 [iff p = q]
  - b. D(p, q) = D(q, p)
  - c. D(p, z) =D(p, q) + D(q, z)
- different Distance measures:
  - a. Euclidean Distance :
  - De(p, q) = [(x-s)^2 + (y-t)^2]
  - b. City Block Distance:
  - D4(p, q) = |x-s| + |y-t|
  - c. Chess Board Distance:
  - D8(p, q) = max(|x-s|, |y-t|)

Detect and Label Connected Components

- *Connected component*
- Connected component labeling
- Connected Set
- Specify a connectivity –
  - 4 connectivity -> two adjoining pixels are part of the same object if they are both on and are connected along the horizontal or vertical direction.





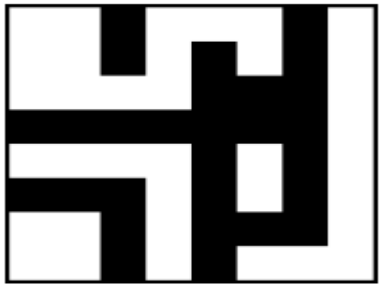
CCL Example:

1	1	0	1	1	1	0	1
1	1	0	1	0	1	0	1
1	1	1	1	0	0	0	1
0	0	0	0	0	0	0	1
1	1	1	1	0	1	0	1
0	0	0	1	0	1	0	1
1	1	0	1	0	0	0	1
1	1	0	1	0	1	1	1

a) binary image

1	1	0	1	1	1	0	2
1	1	0	1	0	1	0	2
1	1	1	1	0	0	0	2
0	0	0	0	0	0	0	2
3	3	3	3	0	4	0	2
0	0	0	3	0	4	0	2
5	5	0	3	0	0	0	2
5	5	0	3	0	2	2	2

b) connected components labeling



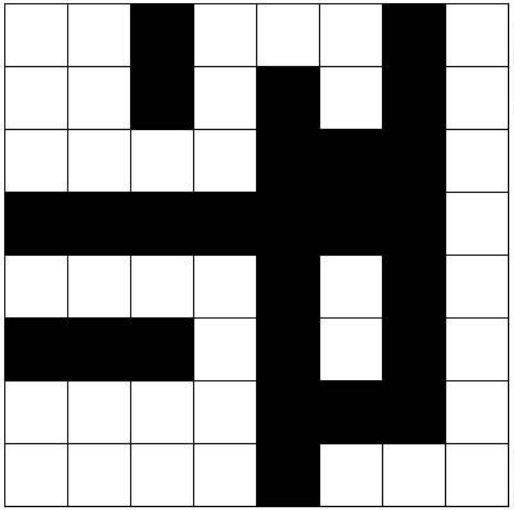
A binary image with 5 connected components.
Connected components labeling is the binary image where the value of each pixel is the label of its connected components.

The recursive algorithm

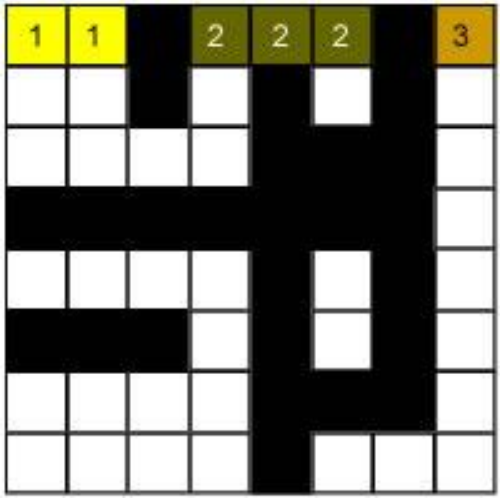
- straightforward algorithm.
- Take a pixel, and check its neighbours for connectivity.
- Inefficient.
- As the image size grows, the time taken by the algorithm increases rather quickly.

CCL- **The classical algorithm**

https://aishack.in/tutorials/labelling-connected-components-example/

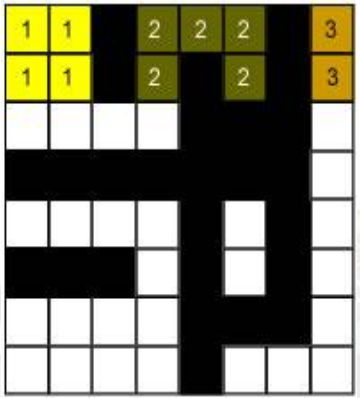


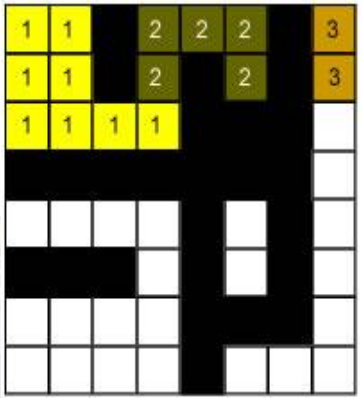
1	1	0	1	1	1	0	1
1	1	0	1	0	1	0	1
1	1	1	1	0	0	0	1
0	0	0	0	0	0	0	1
1	1	1	1	0	1	0	1
0	0	0	1	0	1	0	1
1	1	1	1	0	0	0	1
1	1	1	1	0	1	1	1



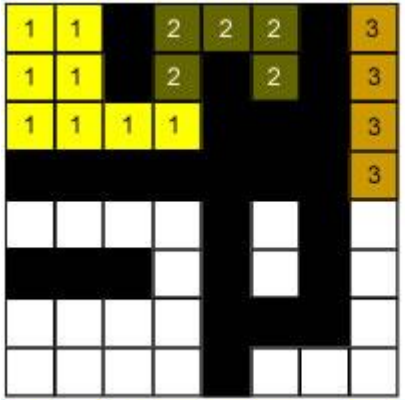
CCL- **continued**

1	1	0	1	1	1	0	1
1	1	0	1	0	1	0	1
1	1	1	1	0	0	0	1
0	0	0	0	0	0	0	1
1	1	1	1	0	1	0	1
0	0	0	1	0	1	0	1
1	1	1	1	0	0	0	1
1	1	1	1	0	1	1	1

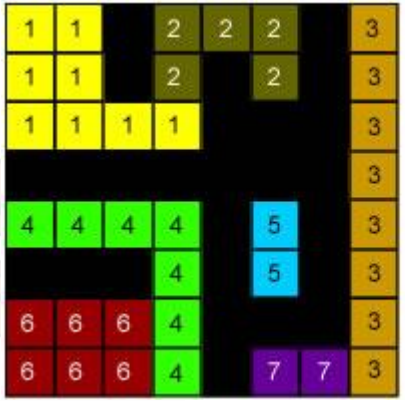




1
2



1
2



1
2
4
6
3
7

CCL- **continued**

1	1	0	1	1	1	0	1
1	1	0	1	0	1	0	1
1	1	1	1	0	0	0	1
0	0	0	0	0	0	0	1
1	1	1	1	0	1	0	1
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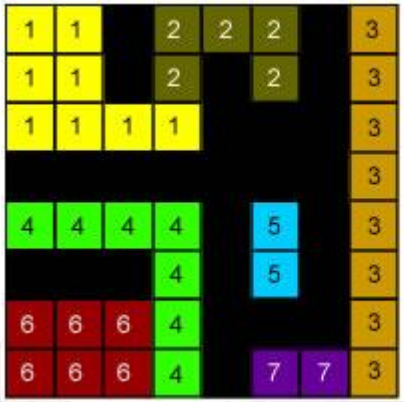
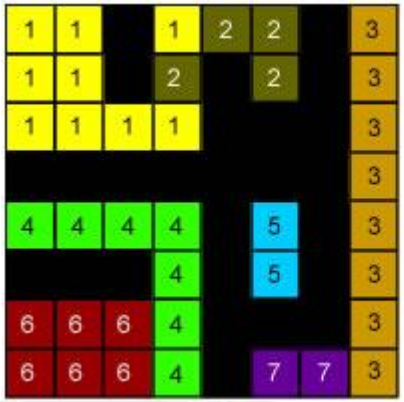
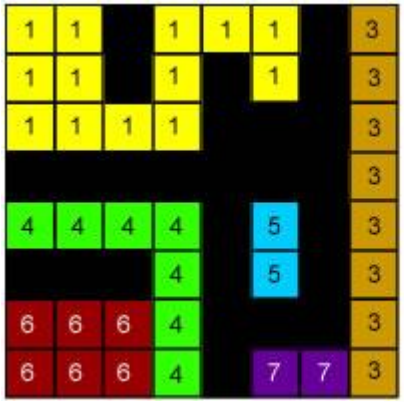
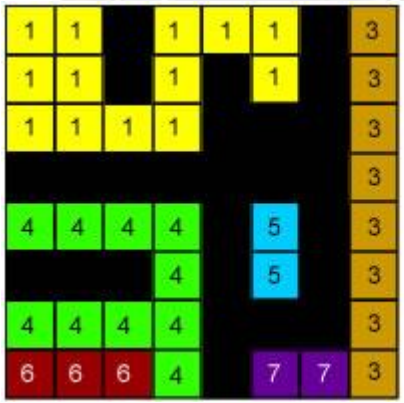
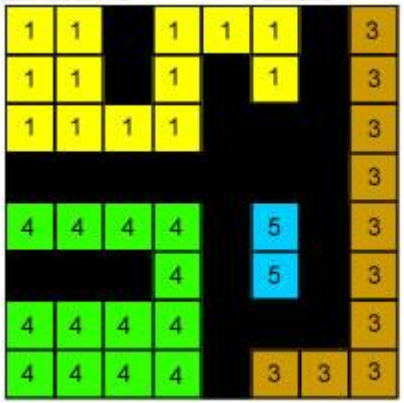
1	1	1	1	0	0	0	1
1	1	1	1	0	1	1	1











Reference Material

- 1. E. R. Davies, “Computer & Machine Vision”, Fourth Edition, Academic Press, 2012.
- 2. R. Szeliski, “Computer Vision: Algorithms and Applications”, Springer 2011.
- 3. Simon J. D. Prince, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012.
- 4. Mark Nixon and Alberto S. Aquado, “Feature Extraction & Image Processing for Computer Vision”, Third Edition, Academic Press, 2012.
- 5. Sunita Dhavale, “Advanced Image-Based Spam Detection and Filtering Techniques”, Book Published by CyberTech: An Imprint of MKP Technologies, Hershey, PA, USA IGI Global, March 2017, ISBN13: 9781683180135|ISBN10: 1683180135|EISBN13: 9781683180142|DOI: 10.4018/978-1-68318-013-5.

<<Epilogue>>

- We will meet in next scheduled lecture.
- Implement and Try codes in python.
- Feel free to ask your questions.
- Email: sunitadhavale@diat.ac.in

Thank You!