4105 Computer Vision

Lecture 2

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Image Matrix

- Assuming Gray level values: $\mathrm{L} = 0 \rightarrow 255$
  - If maximum gray level $\begin{cases} 130 \rightarrow Dark\ Image \\ 255 \rightarrow Has\ no\ meaning \end{cases}$
  - If minimum gray level $\begin{cases} 170\ bright \\ 0\ no\ meaning \end{cases}$
  - (Max & min) $\begin{cases} (100{,}150)\ low\ contrast \\ (0{,}255)\ no\ meaning \end{cases}$
  - $Average \begin{cases} 100 \rightarrow Dark\ Image, more\ than\ bright \\ 50 \rightarrow Dark \\ 200 \rightarrow Bright \\ 127 \rightarrow has\ no\ meaning \end{cases}$
  - $Standard\ deviation\ (Variance) \begin{cases} Big \\ Low \end{cases}$
  - *If (127, Big) as (average, variance): High contrast*
  - *If (127, Low) as (average, variance): Low contrast*

Statistics

max= 255 Min = 0

mean = 101.11 STD DEV 15.9

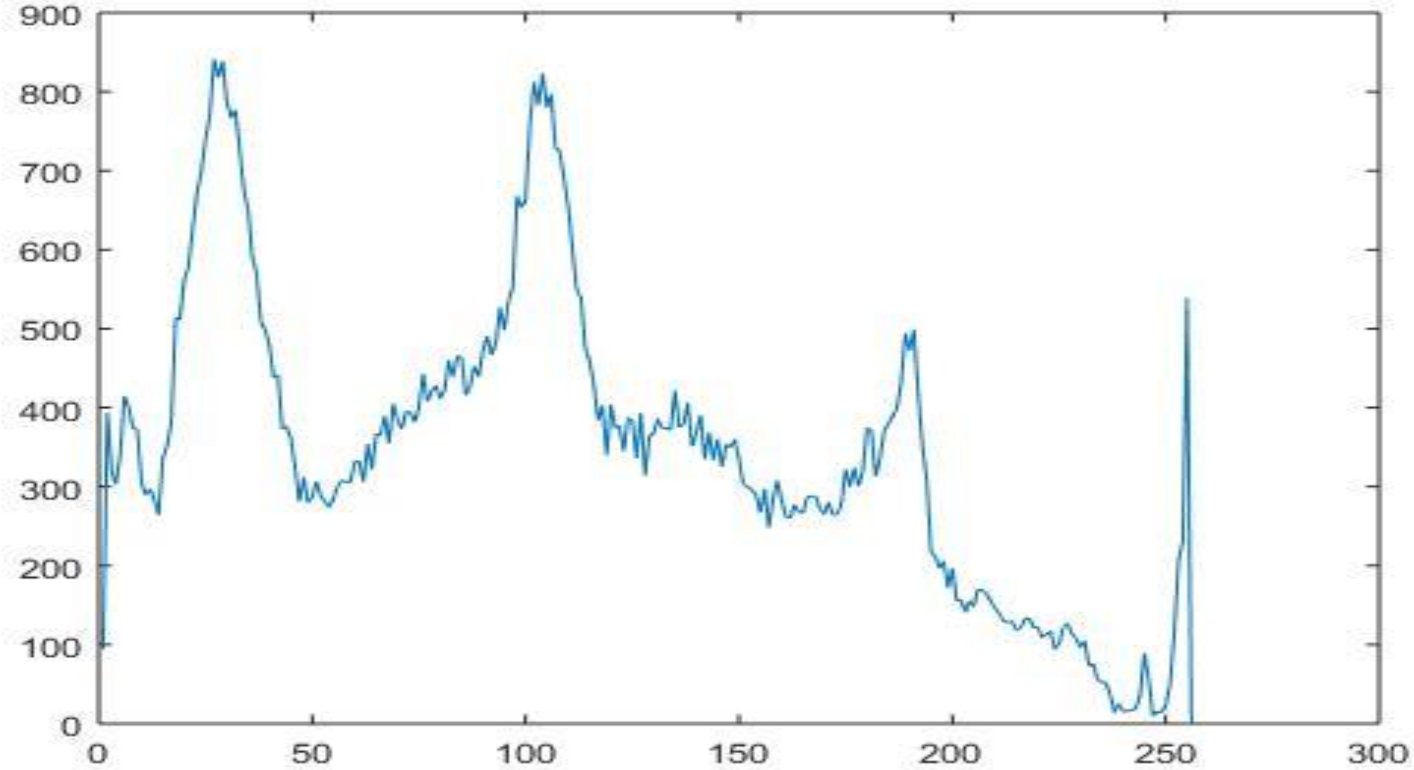
Histogram

- **Histogram:** count the number of occurrences per gray/color component value within the image matrix/matrices.
- So, histogram is a table of two columns : gray/color , counts.
- The total number of counts should be equal to MxN pixel counts
- Histogram is a base
  - Most of elements of image processing

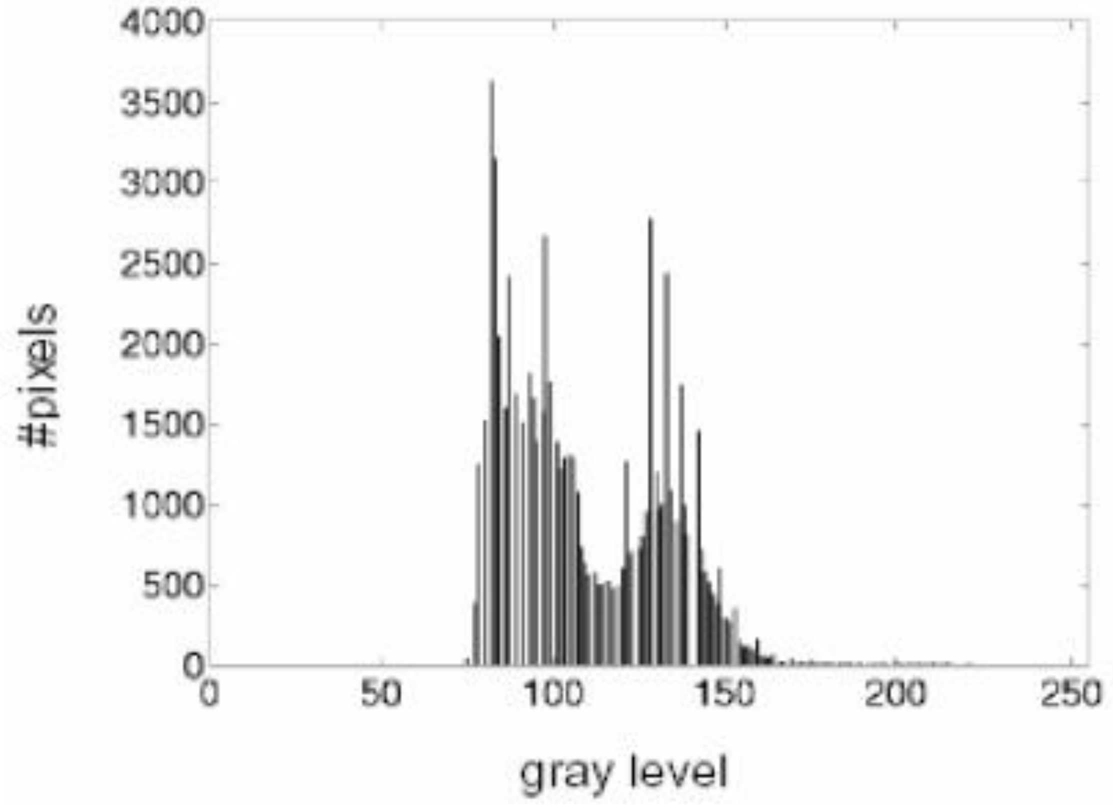
$$\begin{pmatrix} 5 & 5 & 4 & 5 \\ 10 & 20 & 5 & 4 \\ 10 & 20 & 5 & 10 \\ 20 & 4 & 5 & 100 \end{pmatrix}$$

Gray Value	Count
4	3
5	6
10	3
20	3
100	1
Total count(MxN)	16

Histogram



Example Histogram



Pout image

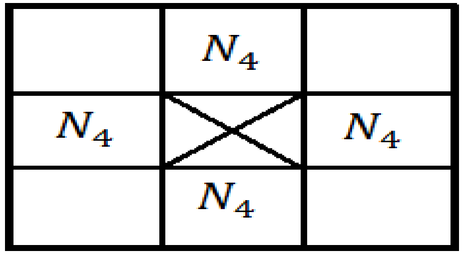
Connectivity and Neighboring

- Generally objects are group of color/gray connected neighbor pixels

Neighboring

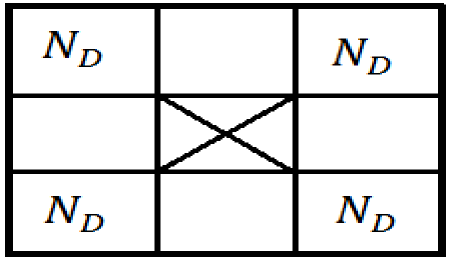
- **Four Neighbors , N4**

$$N_4(f(x,y)) = \{f(x-1,y), f(x+1,y), f(x,y-1), f(x,y+1)\}$$



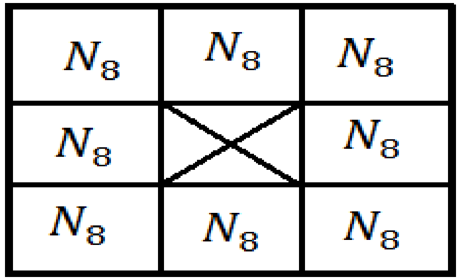
- **Diagonal Neighbors, Nd**

$$N_D\big(f(x,y)\big) = \{f(x-1,y-1), f(x+1,y-1), f(x-1,y+1), f(x+1,y+1)\}$$



- **Eight Neighbors, N8**

$$N_8\big(f(x,y)\big) = \{N_D \cup N_4\}$$



Connectivity

$f(x_1, y_1), f(x_2, y_2)$ Pixels are considered connected if and only if:

- They're neighbors "according to some neighboring"
- $f(x_1, y_1), f(x_2, y_2) \in \xi$ ➔ Where ξ is the gray levels connectivity set $\xi = \{\dots, \dots, \dots, \dots\}$.

Connectivity

- Simple Example: find connected pixels for f(1,1) using N4 and connectivity set $\xi = \{3,4,5,6,7,8,9,10\}$. Redo using Nd, N8

2	4	7
6	5	100
13	120	9

- <u>Image Path:</u>
  - $f(x_1, y_1) \Rightarrow f(x_n, y_n)$
  - The Image path is a sequence of connected pixels starts at the first pixel $f(x_1, y_1)$ and ends at $f(x_n, y_n)$
  - This Path sometimes doesn't exist, could be unique, and could be multiple paths
  - Path $((f(x_1, y_1), f(x_n, y_n))\ is\ = \{f(x_1, y_1), \dots, \dots, \dots, f(x_n, y_n)\}$ where $\{f(x_i, y_i),\ f(x_{i+1}, y_{i+1})\}$ are connected pixels.
  - The Image Path Length is $(n - 1)$

Connectivity

- Connected region
  - A set of pixels of an image such that
    - Between any two pixels inside there exist at least one image path
    - There exits no image path between any other pixel outside and an inside one
  - An object within an image is a connected region

Labeling of Connected Regions

- Labeling is find out the connected regions of an image matrix.
- As a given to the labeling process beside the image matrix the neighboring N *and the connectivity set* ξ
- start from top left pixel then Visit Pixels from Left to Right then top to bottom:-
  - For Each pixel $\begin{cases} f(x,y) \notin \xi \\ f(x,y) \in Connectivity\ set \end{cases}$
    - If: $f(x,y) \notin \xi$
      action: ignore and move to the next one.
    - If: $f(x,y) \in \xi$ Connectivity set then
  - -A) all neighbor pixels or some connected and all in the same label
    action: assign the current pixel to same label
  - -B) all or some of neighbors connected but in different labels
    action: -put the pixel in any label of them
  - - take a note that all these labels are equivalent
  - C :) All Neighbors are not connected
  - Action: - start a new label and assign that pixel to the new label
  - *Continue to visit until the last pixel visited
  - *Join all marked equivalent labels to single label

Distance Metrics

<u>**Distance between Two pixel points $(\boldsymbol{f(x_1, y_1), f(x_2, y_2)})$:-**</u>

- 1) Euclidian: $\Delta(f(x_1, y_1), f(x_2, y_2))$=$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$

- 2) City Blocks: $\Delta\big(f(x_1, y_1), f(x_2, y_2)\big) = |x_1 - x_2| + |y_1 - y_2|$

- 3) Chess Board: $\Delta\big(f(x_1, y_1), f(x_2, y_2)\big) =$ Max $(|x_1 - x_2|\ ,|y_1 - y_2|)$