جامعة اللاذقية
كلية الهندسة المعلوماتية
قسم البرمجيات ونظم المعلومات

Multimedia Systems

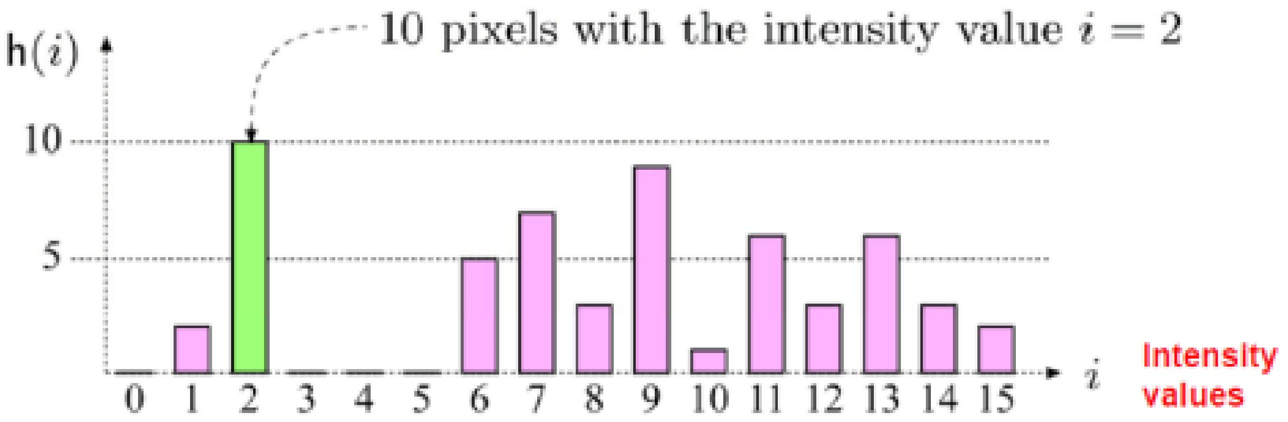
Graphics and Image Data Representation

Lecture 3

Image Histogram

Histograms plots how many times (frequency) each intensity value in image occurs

Only statistical information



i	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
h(i)	0	2	10	0	0	0	5	7	3	9	1	6	3	6	3	2

Image Histogram

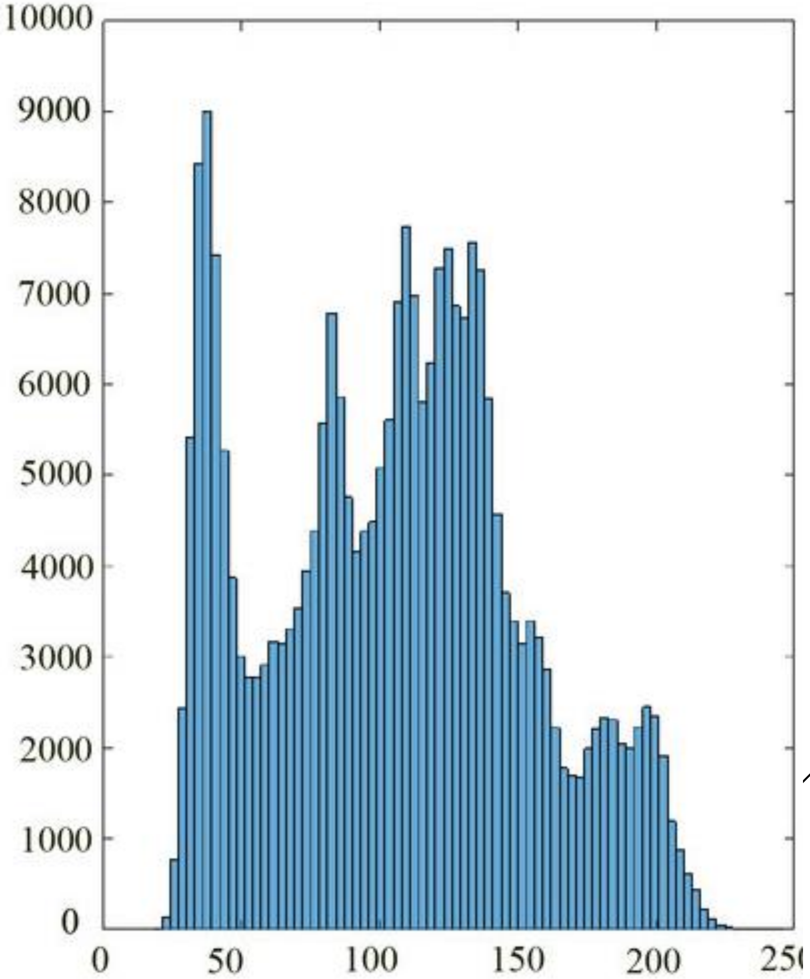
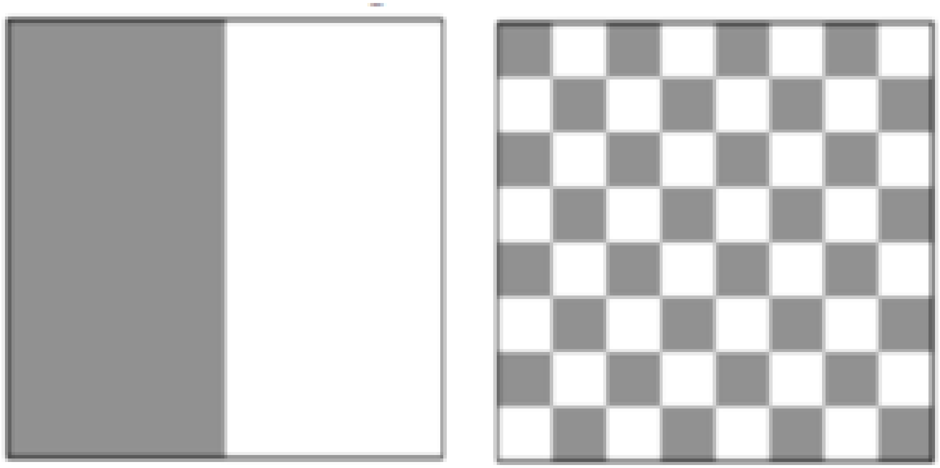


Image Histogram

Distribution of intensities could be different.

What about histogram?

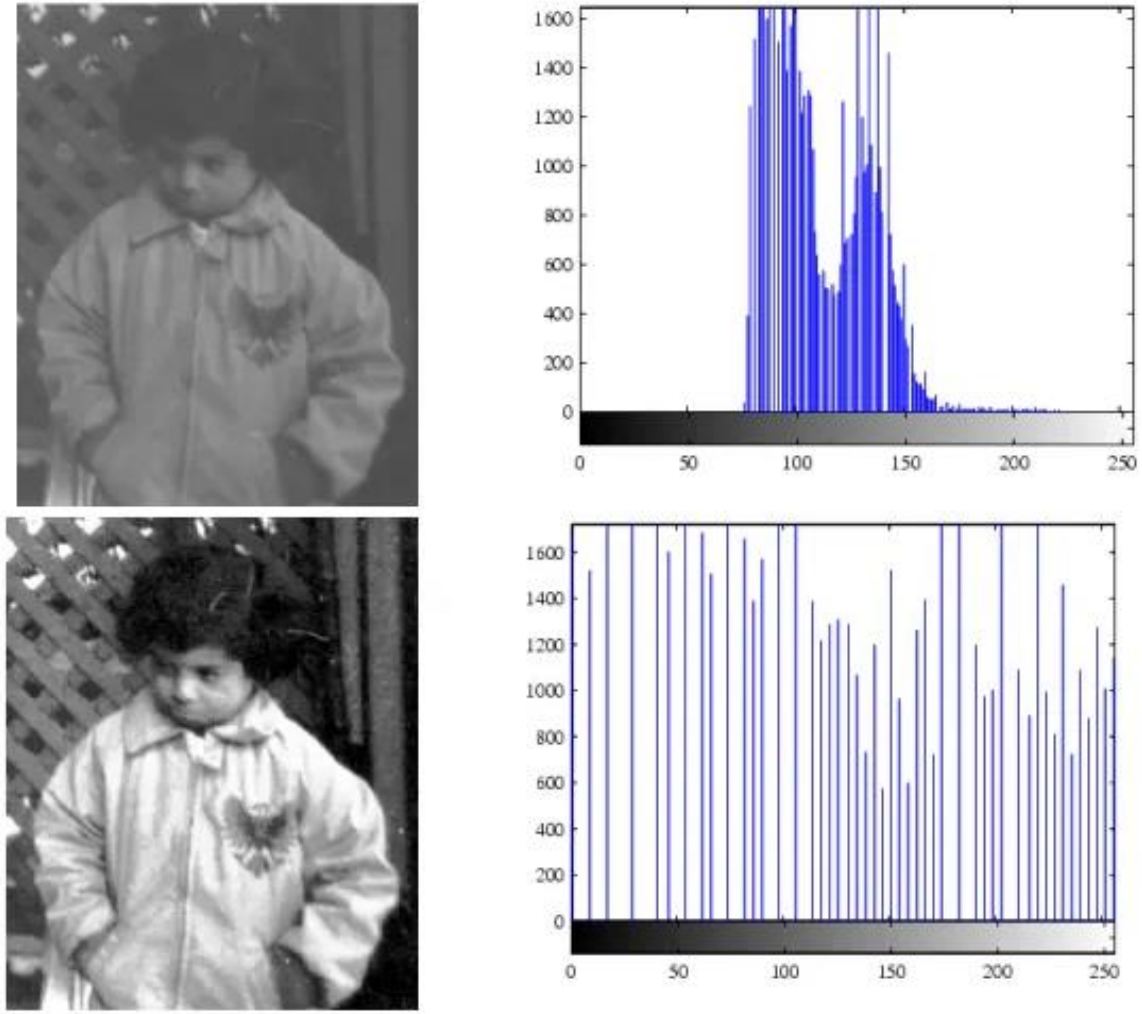


Histogram Equalization

Histogram equalization improves image contrast.

It achieves this by effectively spreading out the most common intensity values, hence expanding out the image's intensity range.

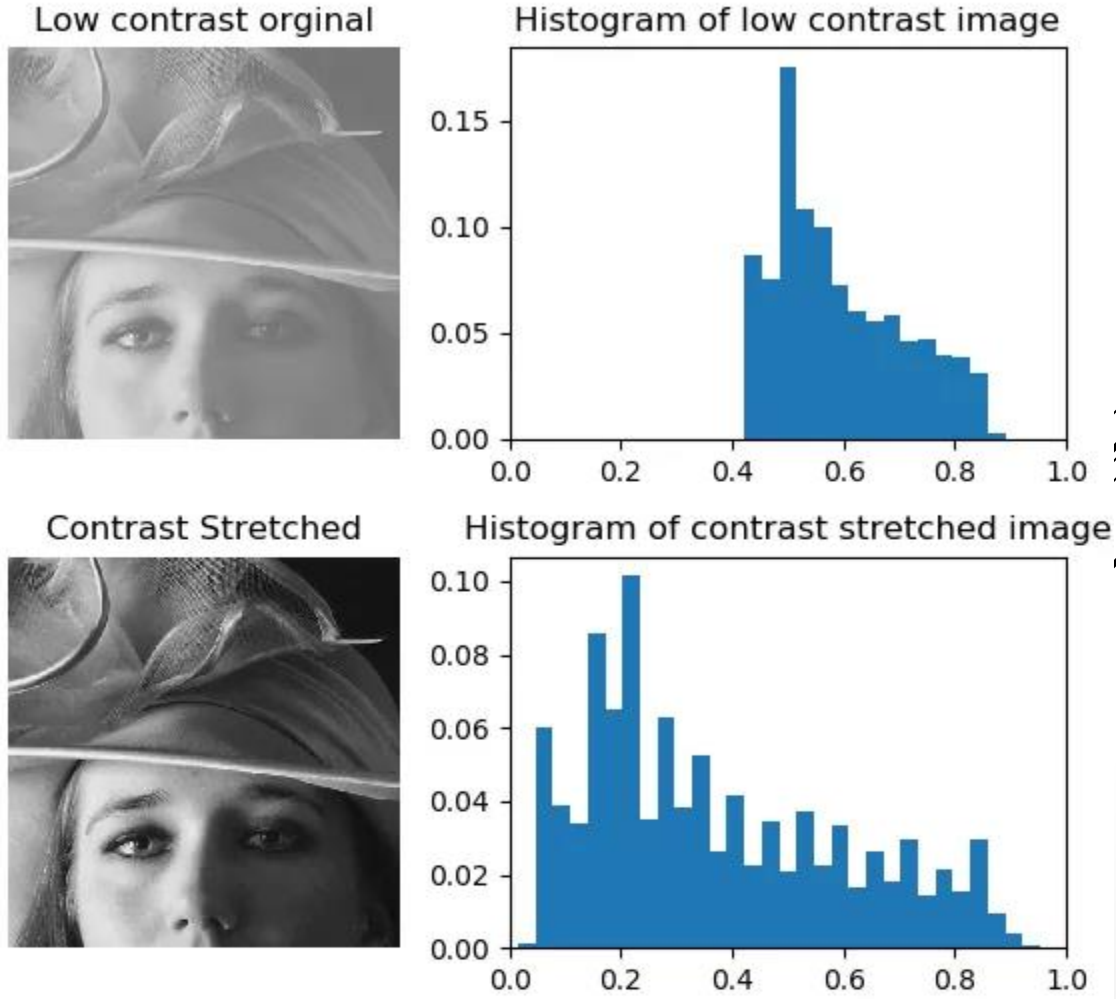
When the useable data in a picture is represented by near contrast values, this approach frequently enhances the global contrast. This permits areas with poor local contrast to gain contrast.



Histogram Equalization

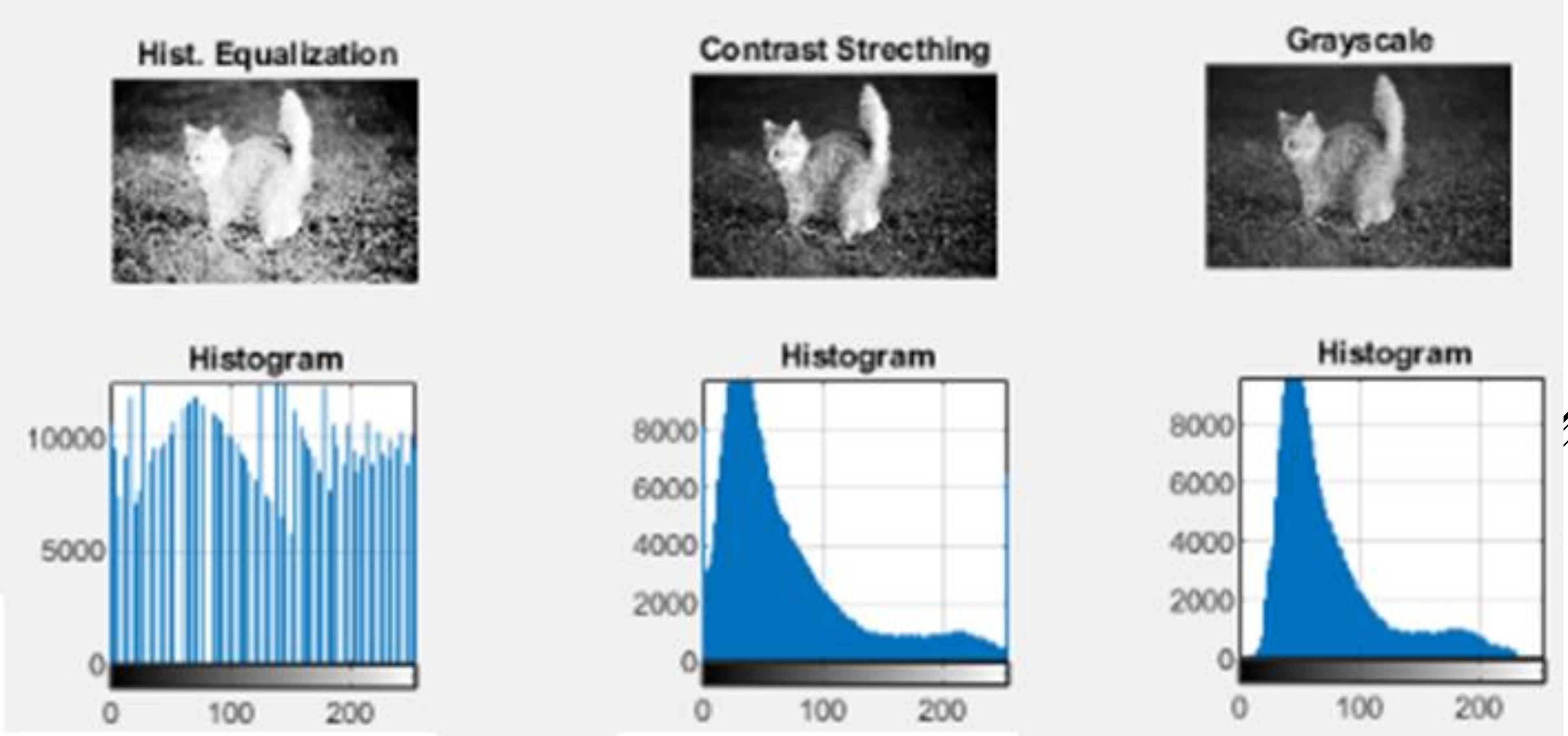
Histogram stretching

Histogram stretching increase picture contrast by extending the range of intensity values included in the image to cover a *desired* range of values.



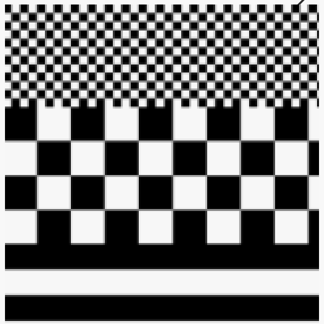
Contrast Stretching

Image Histogram



Relationships between pixels

Relationships between pixels - why

Image Segmentation partitioning an image into multiple segments or regions to simplify its representation or make it more meaningful. 	**Edge Detection** Identifying points in an image where the brightness changes sharply or has discontinuities. 
Noise Reduction Removing unwanted or irrelevant information to improve image quality. 	**Texture Analysis** Texture analysis is used to categorize and describe the texture patterns in images. 

Neighbors of a Pixel

$N_4(p)$: 4-Neighbors of P

Any pixel p(x, y) has two vertical and two horizontal neighbors given by:

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

$N_d(p)$: Diagonal Neighbors of p

Any pixel p(x, y) has four diagonal neighbors, given by

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

N_d	N_4	N_d
N_4	P	N_4
N_d	N_4	N_d

$N_8(p)$: 8-Neighbors of P

The points $N_D(P)$ and $N_4(P)$ are together.

$N_8(P) = N_4(p) \cup N_d(p)$

Adjacency/ Connectivity

Let V be the set of intensity values used to define adjacency,

For binary images à V = {1}

In a gray-scale image, *the idea is the same*, but V typically contains more elements, for example, V = {180, 181, 182, …, 200}

4-adjacency: Two pixels p and q with values from V are 4-adjacent if q is in the set $N_4(p)$.

8-adjacency: Two pixels p and q with values from V are 8-adjacent if q is in the set $N_8(p)$.

m-adjacency: Two pixels p and q with values from V are m-adjacent if**:**

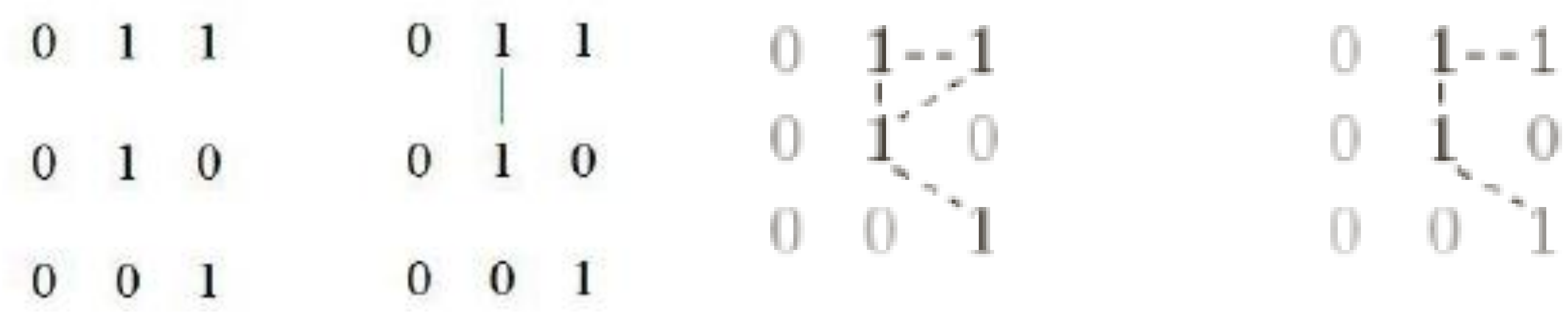
q is in $N_4(p)$

OR

q is in $N_D(p)$ AND $N_4(p) \cap N_4(q)$ has no pixels whose values are from V

Adjacency

Let V be {1}



Pixel arrangement | 4-Adjacent | 8-Adjacent | m-Adjacent

In this example, we can note that to connect between two pixels (finding a path between two pixels):

- In <u>8-adjacency</u> way, you can find multiple paths between two pixels
- While, in m-adjacency, you can find only one path between two pixels

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 (x_0,y_0), (x_1,y_1), …, (x_n,y_n), where (x_0,y_0)= (x,y) and (x_n,y_n)=(s,t), and pixels (x_i,y_i) and (x_{i-1},y_{i-1}) are adjacent for $1 \leq i \leq n$.

n is the **length of the path**

If $(x_0,y_0) = (x_n, y_n)$, the path is ***closed***.

We can specify 4-, 8- or m-paths depending on the type of adjacency specified:

4-adjacency a 4-path

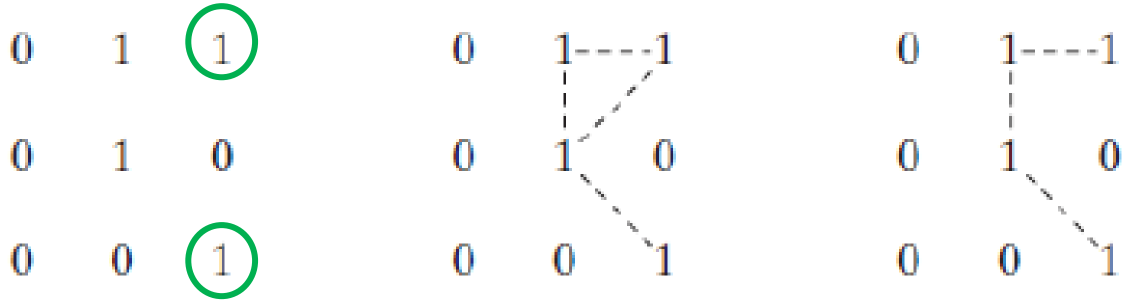
8-adjacency a 8-path

m-adjacency a m-path

path length ? Number of pixels involved

Paths & Path lengths

Example:



(a) Pixel arrangement (b) 8-Adjacent (c) m-Adjacent

figure (b): The paths between the top right and bottom right pixels are 8-paths.

figure (c): the path between the same 2 pixels in is m-path

Connectivity

If p and q are pixels of an image subset S then p is **connected** to q in S if there is a path from p to q consisting entirely of pixels in S.

- For every pixel p in S, the set of pixels in S that are connected to p is called a connected component of S.
- If S has only one connected component then S is called Connected Set.

Connectivity

Example 1:

Let v={1} , How many connected component based on 8 adjacency?

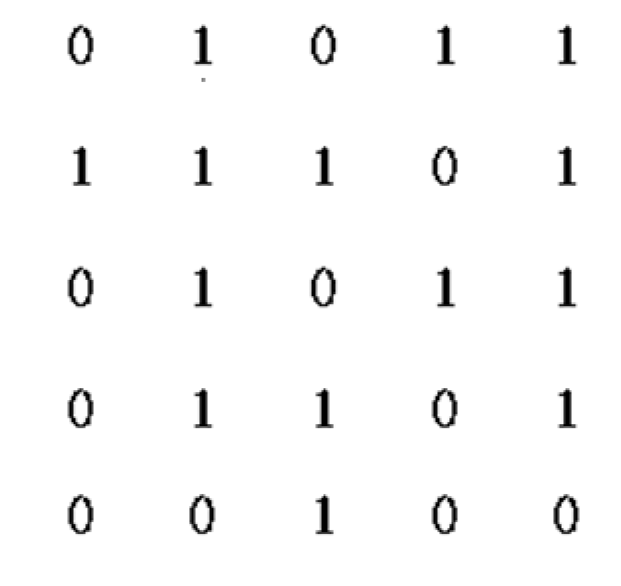
[0, 0, 1, 1, 0]
[0, 1, 1, 0, 0]
[0, 0, 0, 1, 0]
[1, 1, 0, 0, 0]
[0, 0, 0, 0, 1]

[0, 0, 1, 1, 0]
[0, 1, 1, 0, 0]
[0, 0, 0, 1, 0]
[1, 1, 0, 0, 0]
[0, 0, 0, 0, 1]

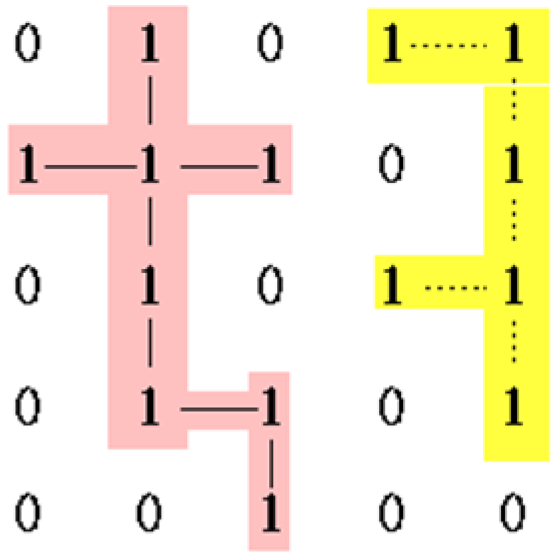
Connectivity

Example 2:

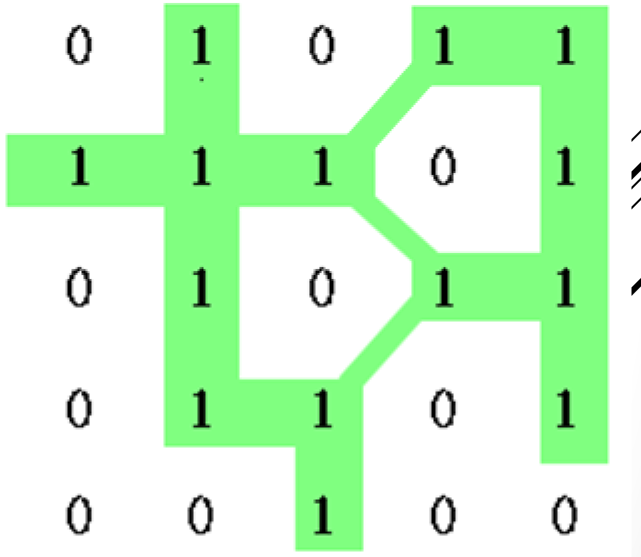
How many connected component?



Arrangement of pixels



Two connected components based on *4*-connectivity



One connected components based on *8*-connectivity

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. $D(p,q) \geq 0$,[$D(p,q) = 0$ iff $p = q$]

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

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

Distance measures

Euclidean distance between p and q:

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

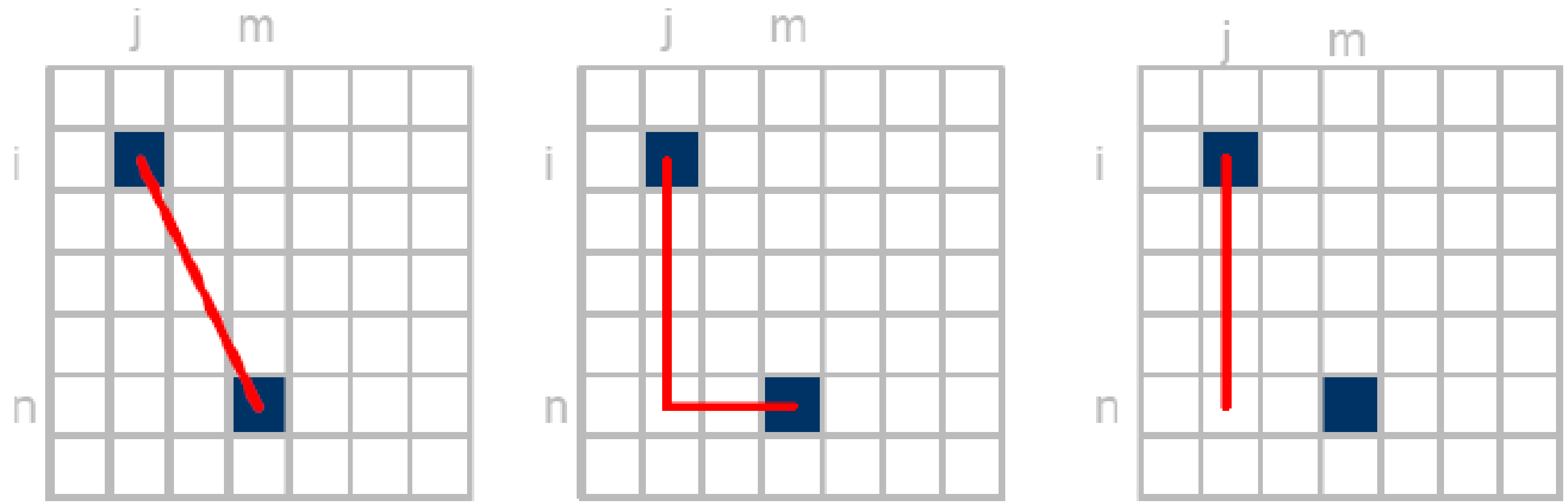
D4 distance (also called city-block distance):

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

D8 distance (also called chessboard distance) :

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

Distance measures



Euclidean Distance

$= \sqrt{(i-n)^2 + (j-m)^2}$

City Block Distance

$= |i-n| + |j-m|$

Chessboard Distance

$= \max[\, |i-n|, |j-m| \,]$

Distance measures

Example:

Compute the distance between the two pixels using the three distances :

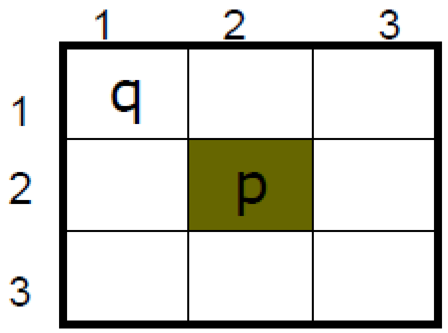
q:(1,1)

P: (2,2)

Euclidian distance = sqrt(2).

D_4(City Block distance) =2

D_8(chessboard distance) = **1** (*it is one of the 8-neighbors*)



Distance measures

Example:

Use the city block distance to prove 4-neighbors ?

Pixel A : | 2-2| + |1-2| = 1

Pixel B: | 3-2| + |2-2| = 1

Pixel C: | 2-2| + |2-3| = 1

Pixel D: | 1-2| + |2-2| = 1

Now try the chessboard distance to proof the 8- neighbors!!!!

	1	2	3
1		d	
2	a	p	c
3		b	

Distance measures

The pixels with distance **$D_4 \le r$** from (x,y) form a diamond centered at (x,y).

The pixels with D_4 = 1 are

the 4-neighbors of (x,y)

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

Distance measures

Pixels with distance $\mathbf{D_8 \leq r}$ from (x,y) form a square centered at (x,y).

e.g: pixels with D_8<=2 from (x,y) form the following contour.

2	2	2	2	2
2	1	1	1	2
2	1	0	1	2
2	1	1	1	2
2	2	2	2	2

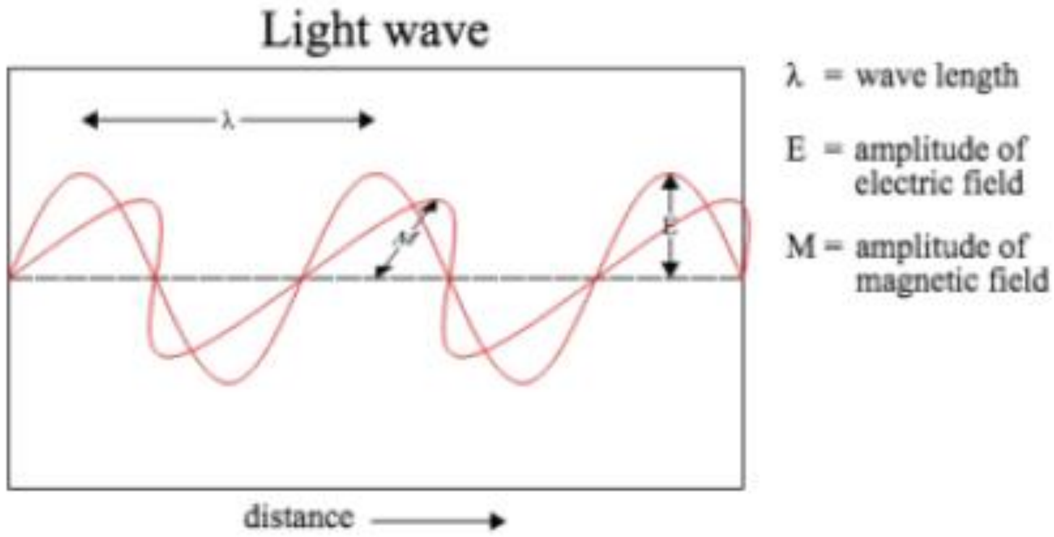
D_8 = 1 are the 8-neighbors of (x,y)

Color in Image and video

Light

Light is a form of energy that can be *seen* by the human eye.

It is an electromagnetic wave which is synchronized oscillations of electric and magnetic fields that propagate at the speed of light through a vacuum or through mediums like air and water.



Light and spectra

Light :

-Most light sources produce contributions over many wavelengths.

- However, humans cannot detect all light, just contributions that fall in the "visible wavelengths".

-Short wavelengths produce a blue sensation, long wavelengths produce a red one.

Visible light :

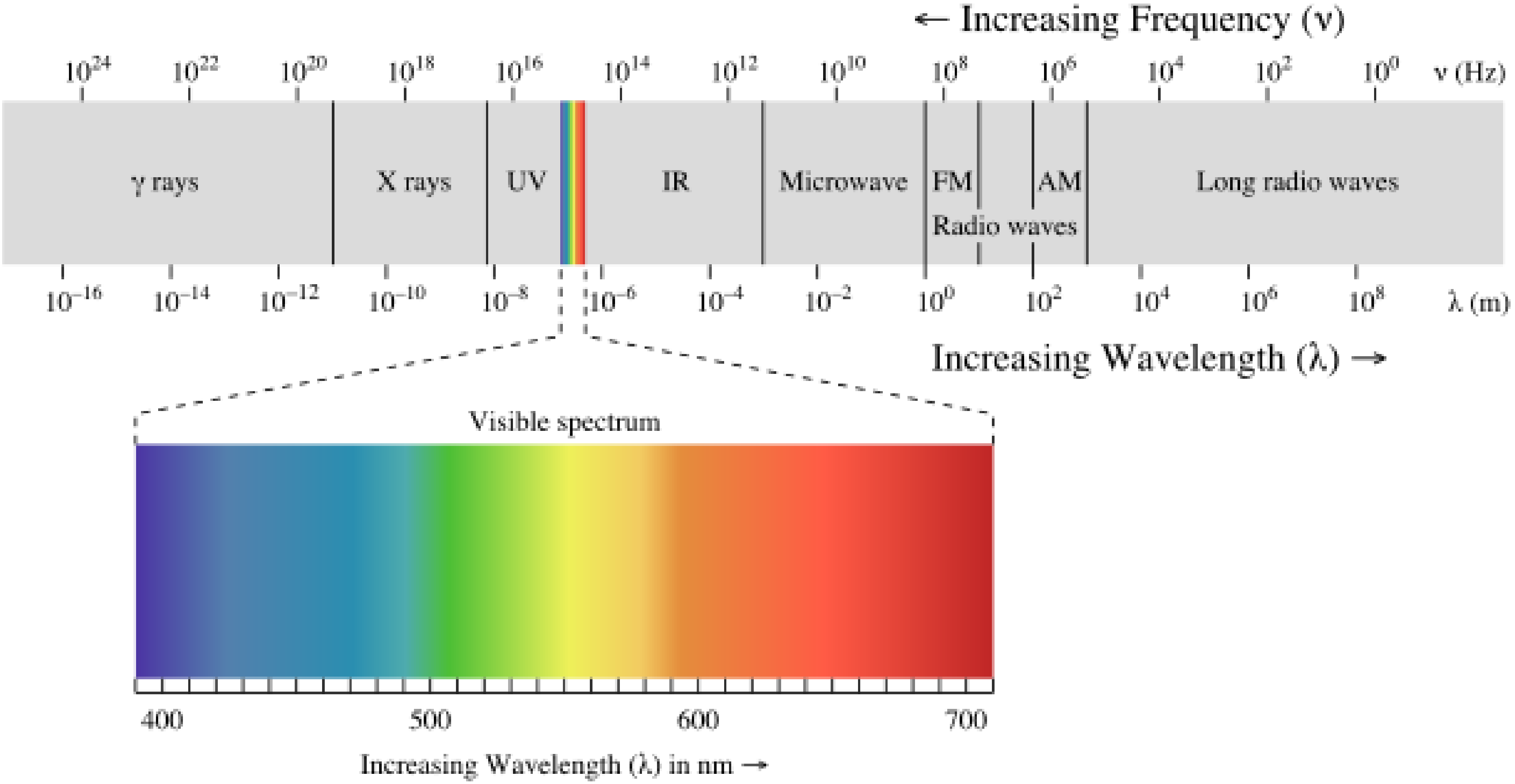
is an electromagnetic wave in the range **380 nm to 700 nm**

(nm stands for nanometer ,10^-9 meters)

Light and spectra

The **spectrum** is a range of ***colors or frequencies*** that can be produced by a light source. It can refer to the visible spectrum, which includes the colors that can be seen by the human eye (such as red, orange, yellow, green, blue, indigo, and violet), or to the broader electromagnetic spectrum that includes infrared, ultraviolet, X-rays, and more.

Light and spectra



Electromagnetic spectrum

Light and spectra

Colors are the result of *light* interacting with the *human eye*. We have three primary colors: Red, Green, and Blue (RGB). These three colors can be combined to create other colors.

Color is not a physical property …

This perception of color derives from the stimulation of cone cells in the human eye by electromagnetic radiation in the spectrum of light.

Colors of objects:

from light leaving their surfaces, which normally depends on the spectrum of the incident illumination and the reflectance properties of the surface

Spectral Power Distribution (SPD):

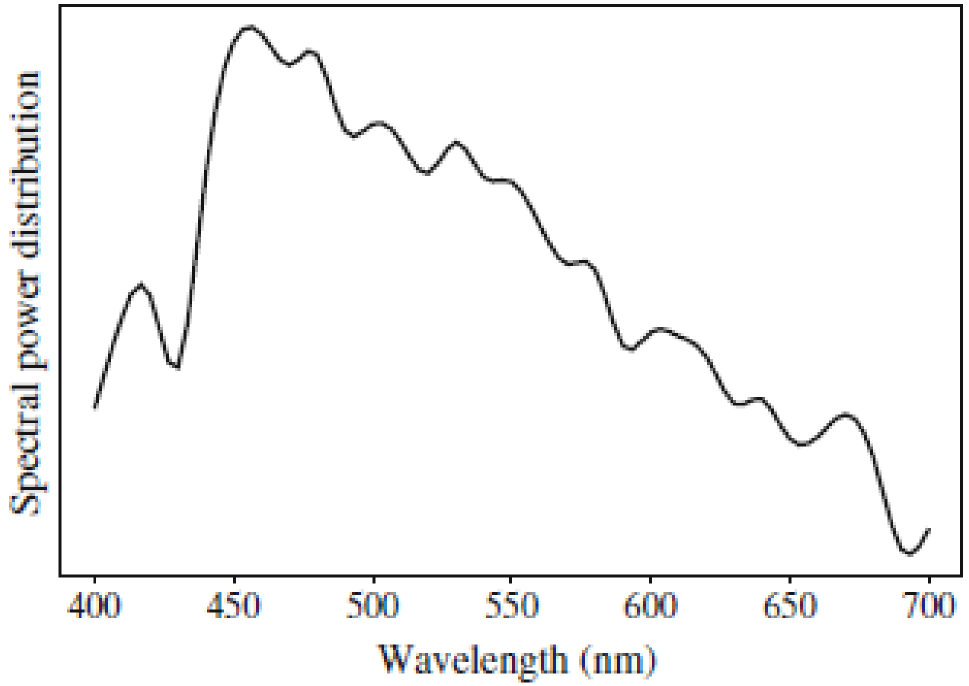
Spectral Power Distribution (SPD) shows the relative amount of light energy in each wavelength. SPD helps in understanding how light interacts with different materials.

SPD is also important in image processing, as it affects how cameras perceive colors and details in images. When designing lighting systems or cameras, it is essential to consider the SPD to ensure color accuracy and clarity.

Spectral Power Distribution (SPD):

This figure shows the relative amount of light energy (electromagnetic signal) at each wavelength.

- The symbol for wavelength is (lambda)λ. This curve is called E(λ).



SPD of daylight

End of introduction lecture