Procesamiento de Señales e Imagenes

Ingeniería Biomédica

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Procesamiento de imágenes

What is Digital Image Processing?

Definition

- Two-dimensional function, f(x, y)
- Where x and y are spatial coordinates.
- The amplitude of f at any pair of coordinates (x, y) is called the intensity.

The digital image

If the coordinates and the intensity are discrete quantities the image turns into a digital image.

What is Digital Image Processing?

Definition

A digital image is composed by a finite number of elements called PIXEL.

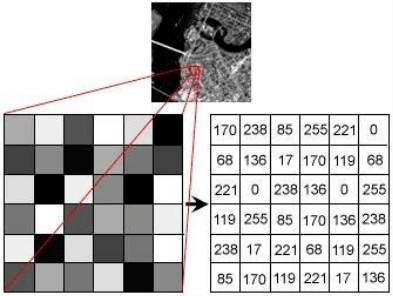


Figura 1:
https://www.researchgate.net/figure/Digital-image-representation-by-pixels

Depth

A digital image is composed by a finite number of elements called PIXEL. Bpp(Bits per pixel)

- 1bpp. B/W image, monochrome.
- 2bpp. CGA Image.

What is Digital Image Processing?

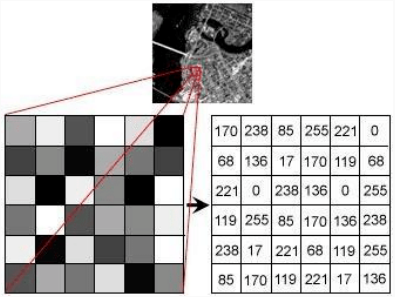


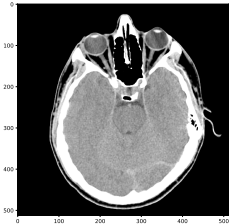
Figura 2:
https://www.researchgate.net/figure/Digital-image-representation-by-pixels-vii_fig2_311806469

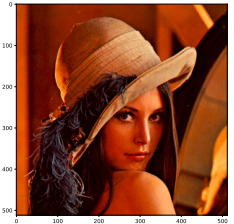
Color Space

How can i represent the color

- RGB.
- CMYK.
- HSV.
- Among others.

What is Digital Image Processing?






```
import cv2
import matplotlib.pyplot as pl

img = cv2.imread(image_path+"i
fig001 = plt.figure()
plt.imshow(img)
```

```
import cv2
import matplotlib.pyplot as plt

img = cv2.imread(image_path+"le
RGB_img = cv2.cvtColor(img, cv2
fig002 = plt.figure()
plt.imshow(RGB_img)
```

Images and vision

- The paradigm surrounding the conceptualization of light and perception has undergone significant evolution.
- Initially, the prevailing understanding within humanity posited that visual stimuli emanated from the eye itself.
- However, contemporary knowledge has elucidated that light originates from external sources, undergoes reflection from objects within the environment, and is subsequently captured by the eye.

Important

We also understand that light is a type of electromagnetic radiation, and its wavelength falls within a range from 400 nanometers to 700 nanometers.

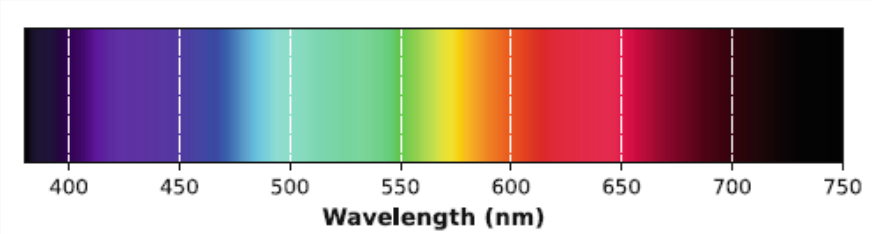


Figura 3: Taken from Corke 2023

Important

- The most common way light is made is by something getting really hot. This makes energy that comes out as light.
- Some important term are:
  - *Absortion:* It is the fraction of light which a body absorbs depending on the wavelength.
  - *Reflectance:* It is the fraction of the incoming light which a body reflects. It's a number between 0 to 1 and also depends on wavelength.
  - *Luminance:* It is the fraction of the incoming light which a surface reflects. It's a function of absortion and reflectance, and because of that luminance depends on wavelength.

The eye

- Our eye has two types of cells. *Cones* and *Rods*.
- Cones are the most sensitive cells but above all these are color sensitive.
- Rods responds only two intensity and they used on night, mostly.
- Humans, like most primates, are trichomats. This means that humans have three types of cones (Long, Medium and shorts).
  - 65 % of longs (Sense red)
  - 33 % of mediums (Sense green)
  - 2 % of shortsv(Sense blue)

The artificial eye

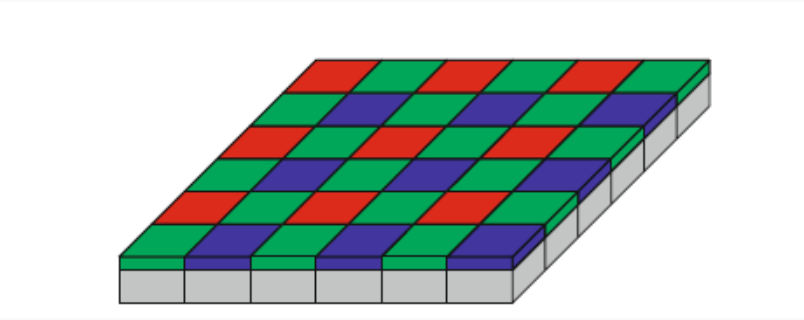
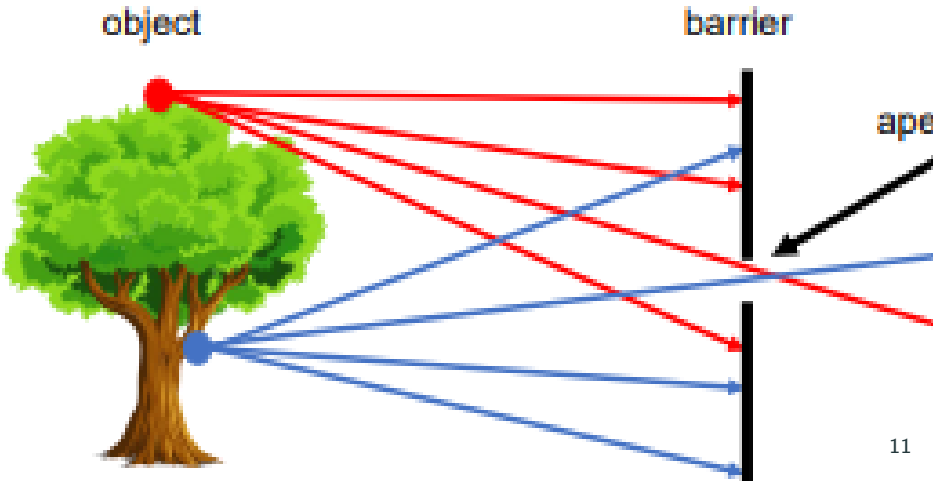
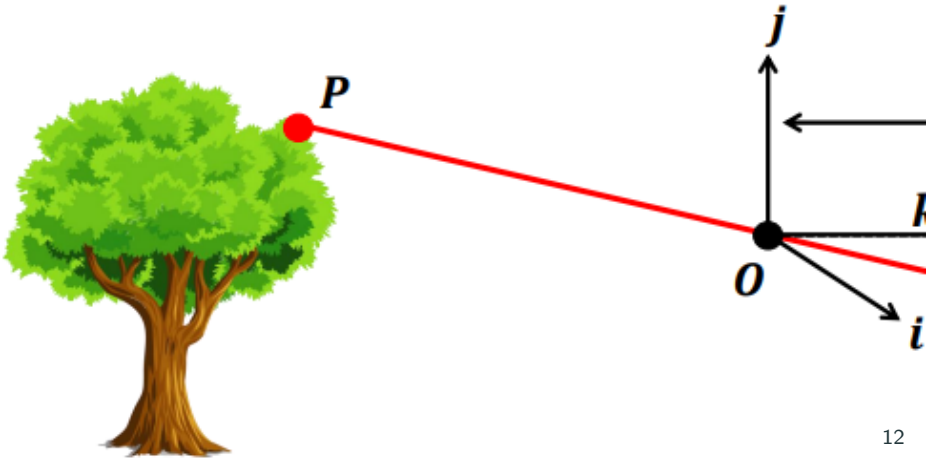


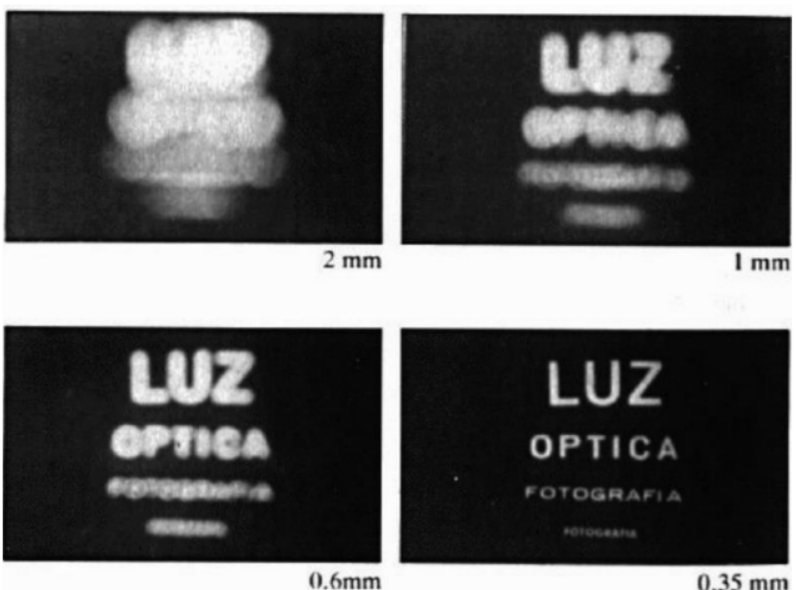
Figura 4: Taken from Corke 2023

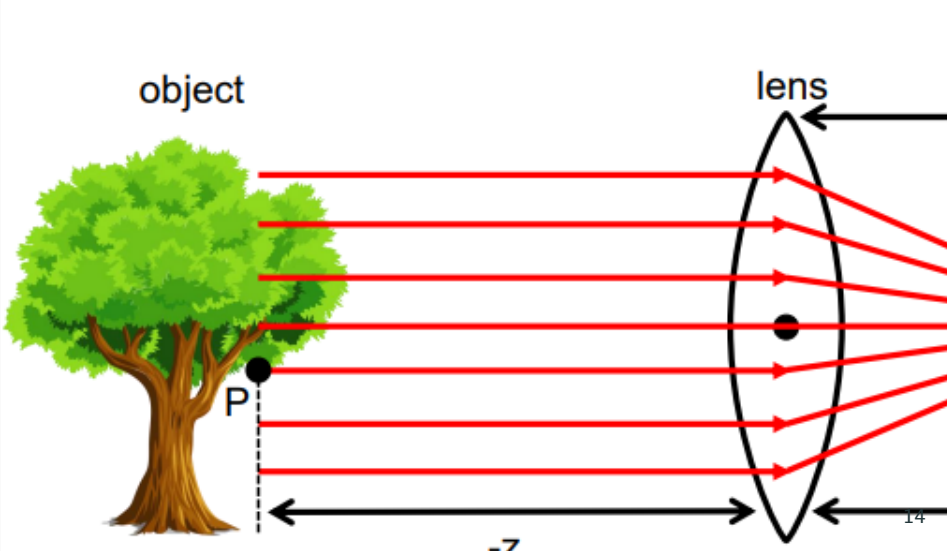
The currents from each sensor are function of the luminance and the

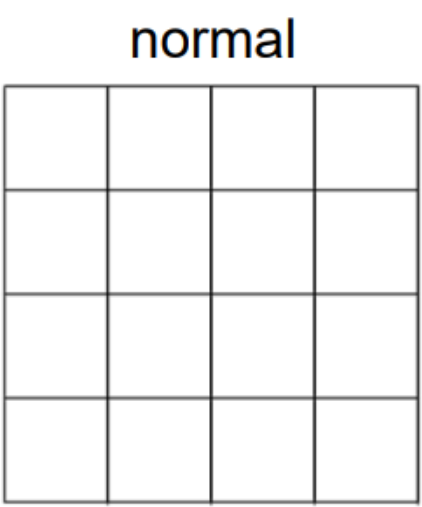

object
barrier
ape


P
j
O
i

Images and vision




object
lens
P
-z


normal
pincushion

Sampling and quantization

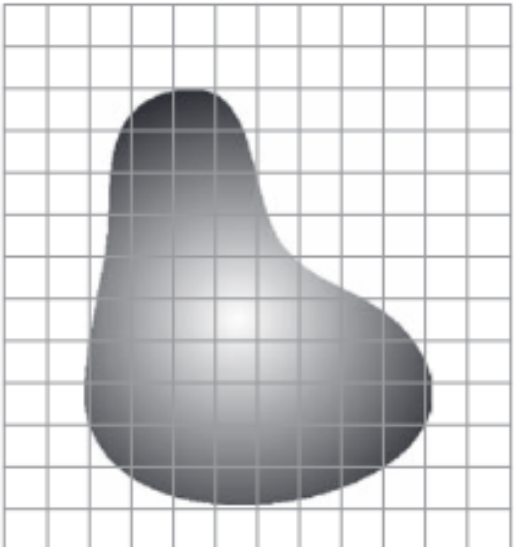
Definition

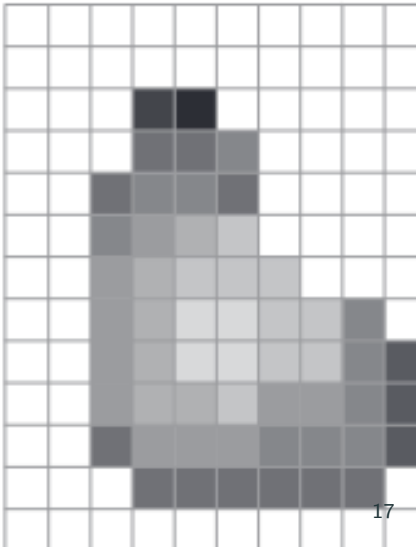
Sampling: Digitalization of the spatial coordinates.

Definition

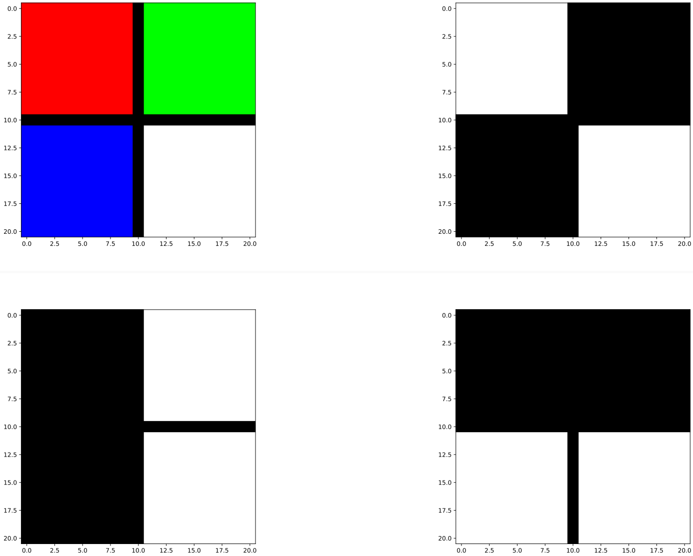
Quantiazation: Digitalization of the light intensity (amplitude).

Sampling and quantization

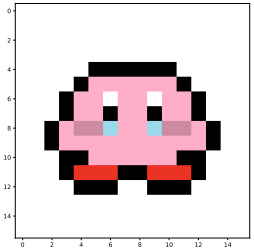


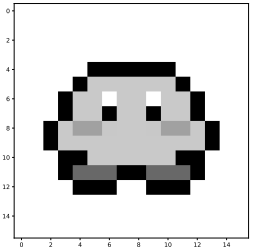


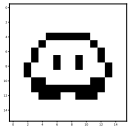
Sampling and quantization



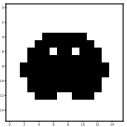
Sampling and quantization



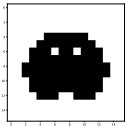




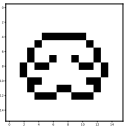
(a) 1bit



(a) 2bit

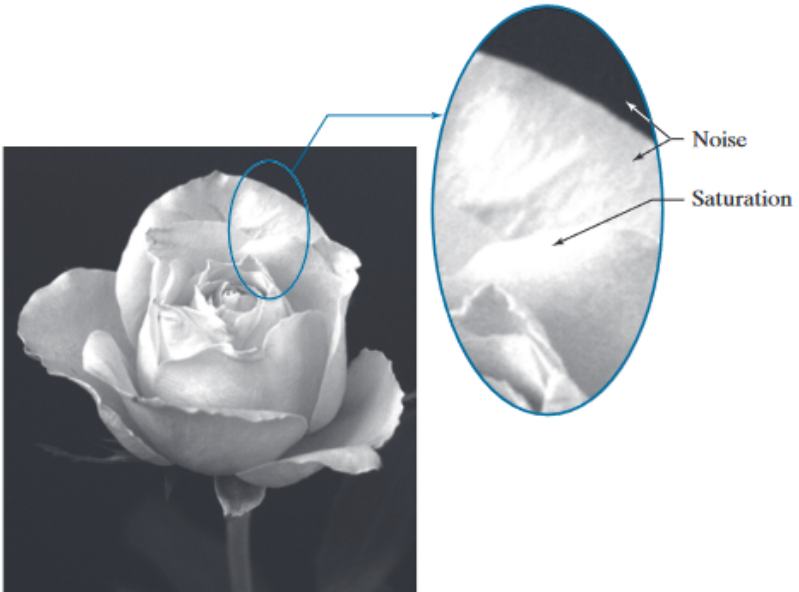


(a) 3bit

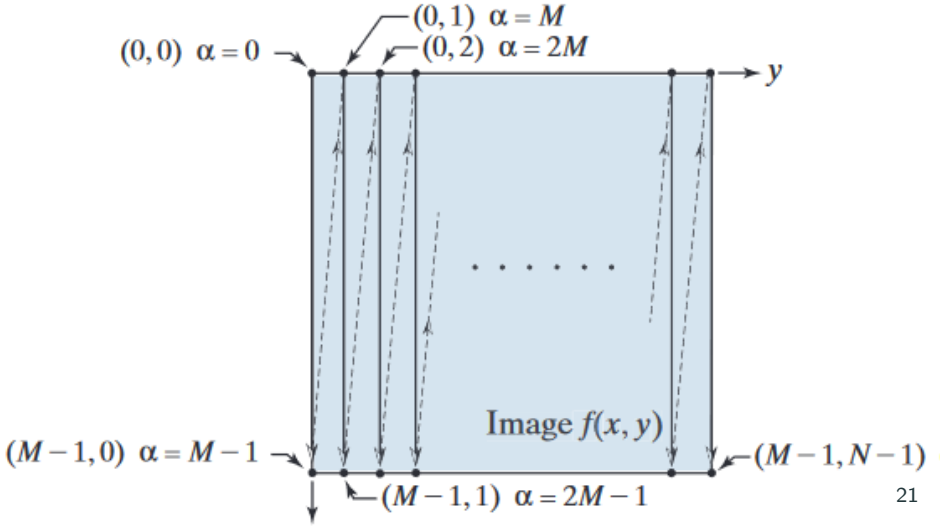


(a) 4bit

Sampling and quantization



Linear indexing



Spatial resolution

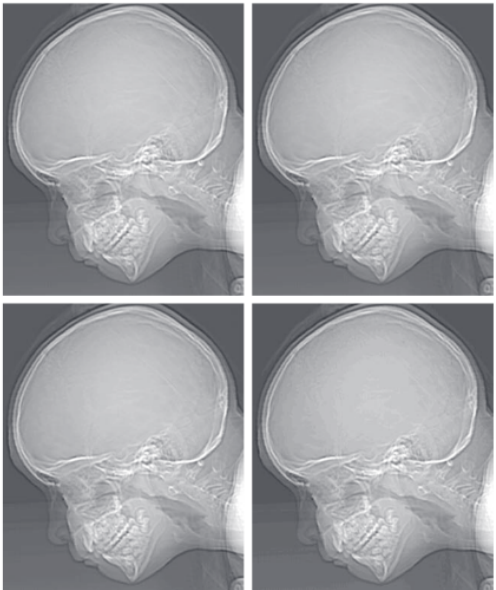
a b
c d

FIGURE 2.23
Effects of reducing spatial resolution. The images shown are at:
(a) 930 dpi,
(b) 300 dpi,
(c) 150 dpi, and
(d) 72 dpi.

Intensity resolution

a b
c d

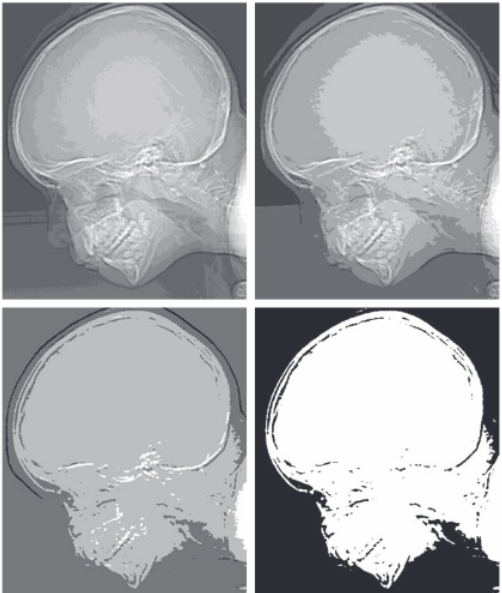
FIGURE 2.24
(a) 774 × 640, 256-level image. (b)-(d) Image displayed in 128, 64, and 32 intensity levels, while keeping the spatial resolution constant. (Original image courtesy of the Dr. David R. Pickens, Department of Radiology & Radiological Sciences, Vanderbilt University Medical Center.)



Intensity resolution

e f
g h

FIGURE 2.24
(*Continued*)
(e)-(h) Image displayed in 16, 8, 4, and 2 intensity levels.



“A simple problem”

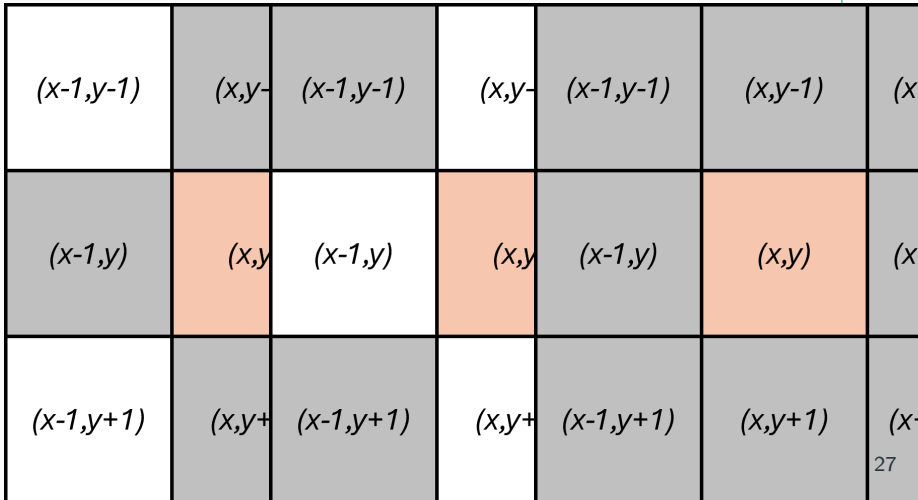
Image

“A simple problem”

Semantic Segmentation

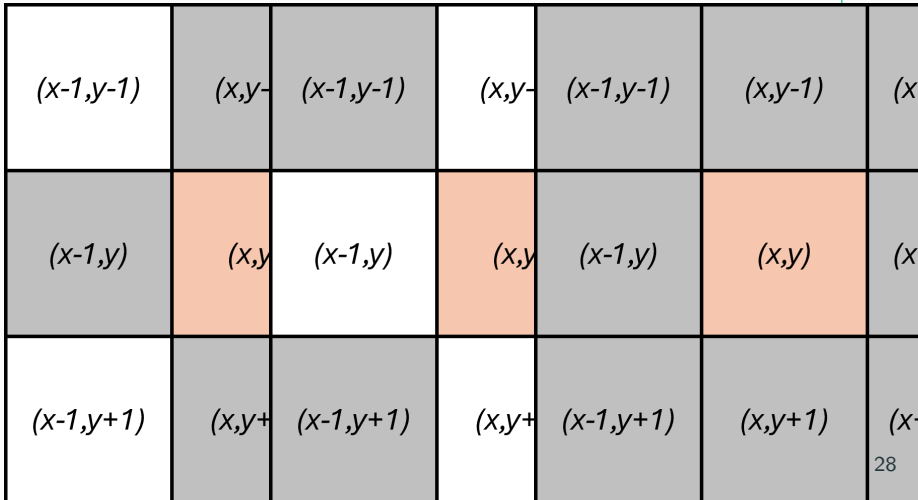
Relationships between pixels

Neighborhood



Relationships between pixels – Neighborhood

Neighborhood



Relationships between pixels – Adjacency

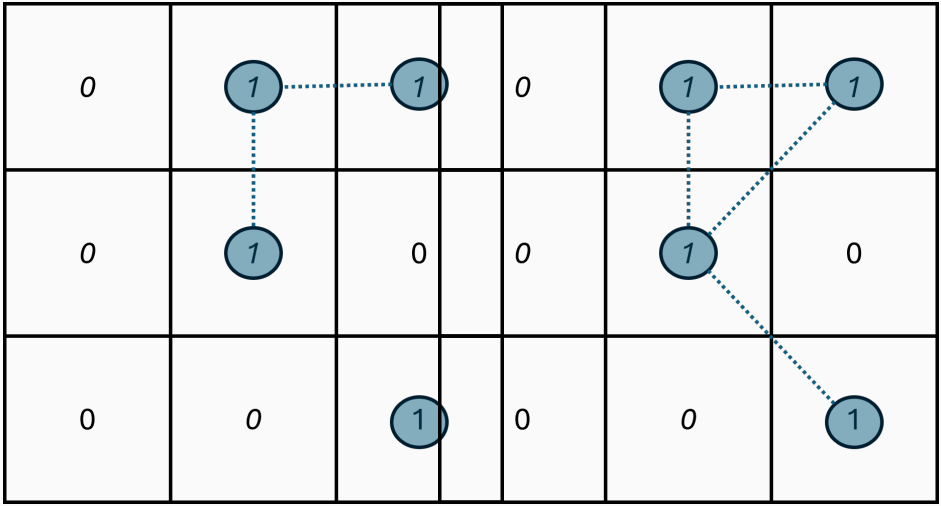
Rules for adjecency

- 4-Adjecncy: 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 (also called mixed adjacency). Two pixels p and q with values from V are m-adjacent if:
  - q is in $N_4(p)$.
  - q is in $N_D(p)$ and the set $N_4(p) \cap N_4(q)$ has no pixels whose values are from V.

Relationships between pixels

0	*1*	*1*
0	*1*	0
0	*0*	1

Relationships between pixels



(a) A4 **(a)** A8

Relationships between pixels – Path

Digital path

It is a sequence of adjacent pixels.

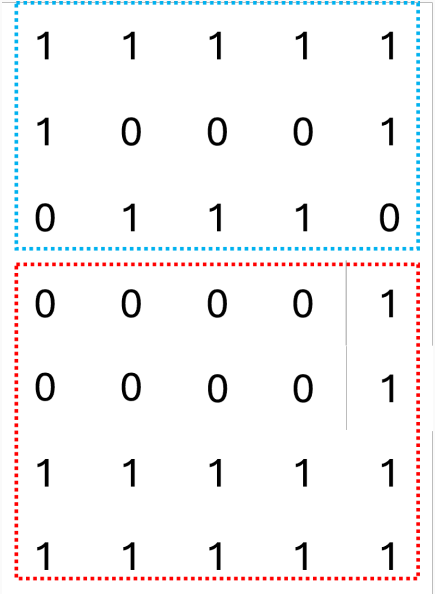
$$(x_0, y_0), (x_1, y_1), (x_2, y_2), \ldots (x_n, y_n)$$

If $(x_0, y_0) = (x_n, y_n)$ the path is known as closed path
Let S represent a subset of pixels in an image. Two pixels p and q are said to be connected in S if there exists a path between them consisting entirely of pixels in S.

Relationships between pixels – Path, Connected Subset

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

Relationships between pixels – Regions



Relationships between pixels – Boundary

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

Relationships between pixels – Distance

Distance

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

- **City block distance**: $D_4(p,q) = |x-u| + |y-v|$
- Chessboard distance: $D_8(p,q) = max\left(|x-u|, |y-v|\right)$
- Euclidean distance: $D_e(p,q) = \sqrt{(x-u)^2 + (y-v)^2}$

Relationships between pixels

Distance

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

- City block distance: $D_4(p,q) = |x-u| + |y-v|$
- **Chessboard distance**: $D_8(p,q) = max\left(|x-u|, |y-v|\right)$
- Euclidean distance: $D_e(p,q) = \sqrt{(x-u)^2 + (y-v)^2}$