PAM3012
Digital Image Processing for Radiographers

Image Sensing and Acquisition

In this lecture

- ★Single sensor acquisition
- ★Line sensor acquisition
- ★Array sensor acquisition
- ★Model of image formation
- ★Representation of the Digital Image

Image Formation

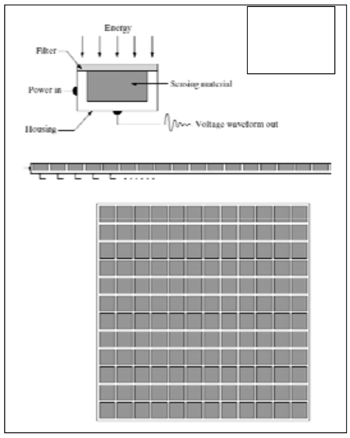
<u>General Form</u>

- 'Illumination source'
- Reflected or Transmitted by 'scene'
- Detector

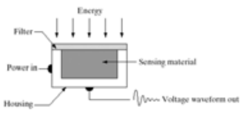
Sensors

Three principle types of detector used to used to transform illumination energy into digital image

1. Single Sensor
2. Line Sensor
3. Array Sensor



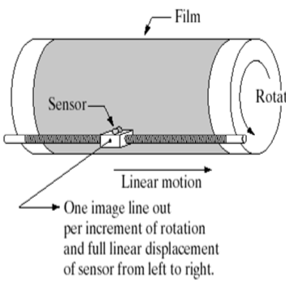
Sensors



- Transform incoming energy into an electric signal
  - Input electrical power
  - Sensor material is responsive to particular type of energy being detected
- Output waveform is digitised

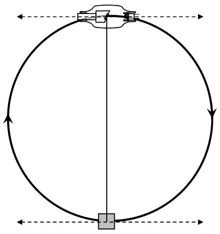
Single Sensor

- 2D image generated by displacement in x- and y- directions



Single Sensor

- Example: First Generation CT

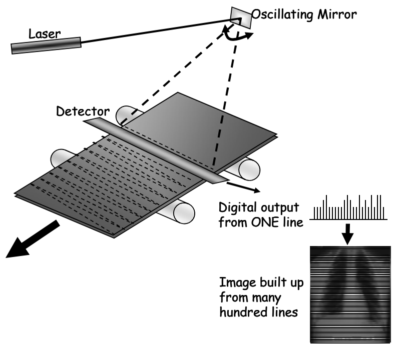


- Single Sensor
- 2D image achieved by
  - Lateral steps
  - Rotation
- Computer converts data into square matrix

Single Sensor

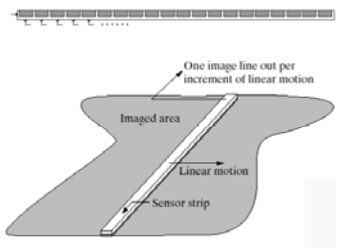
Example:

- Single point laser scanner
- Computed Radiography



Line Sensor

- Strip gives one line of an image at a time
- Perpendicular motion provides imaging in other



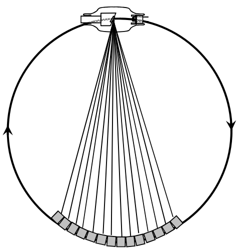
Line Sensor

Example:

- Flatbed scanner
- Film scanner

Line Sensor

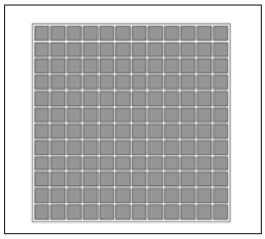
- Example: Third Generation CT



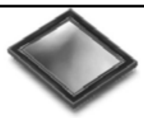
- Line Sensor
- 2D image achieved by
  - Rotation
  - Linear patient motion
- Computer converts data into square matrix

Sensor Array

- Incoming energy is focused to for ‘image’ on sensor array

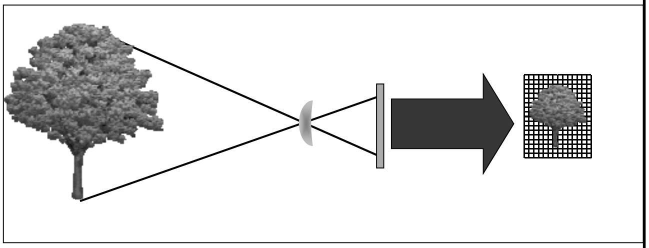


Sensor Array



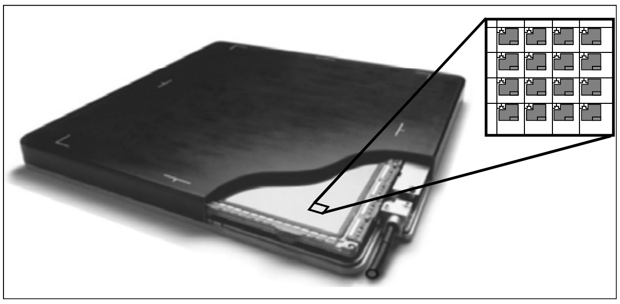
Example:

- Digital Camera
  - Sensor: CCD array



Sensor Array

- Example: Direct Digital Radiography

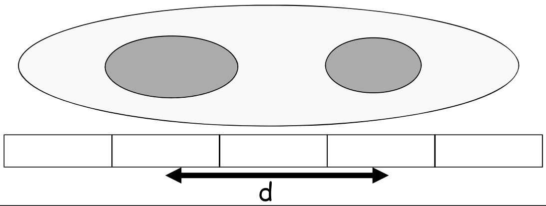


Spatial Resolution

- A measure of the accuracy or detail of an imaging system
- Expressed as dots per inch (pdi), pixels per line, lines mm^{-1}, cycles mm^{-1}
- The minimum distance between two independently measured objects that can be distinguished

Spatial Resolution

- Objects must be separated by at least one pixel to be discriminated



Spatial Resolution

- Use similar triangles

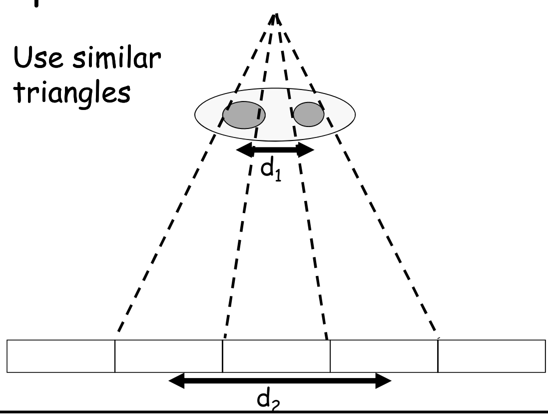


Image Formation Model

- 2-Dimensional Function - $f(x, y)$
  - Value at spatial co-ordinate (x, y)
  - Positive scalar quantity
  - Physical quantity determined by source of image
  - Value proportional to energy radiated by source
  - $0 < f(x, y) < \infty$

Image Formation Model

f (x, y) has two components

1. Intensity of illumination *i(x, y)*
2. Intensity reflection or transmission coefficients *r(x, y) or t(x, y)*

$f(x,y) = i(x,y) \times r(x,y)$ $f(x,y) = i(x,y) \times t(x,y)$

- Where $0 < i(x, y) < \infty$
- and $0 < r(x, y) < 1$ and $0 < t(x, y) < 1$

Typical Values

i(x, y) for visible light

- On a clear day at the earth's surface, the sun: ~90,000 lm/m^2
- On a cloudily day at the earth's surface, the sun: ~10,000 lm/m^2
- On a clear night at the earth's surface, the moon: ~0.1 lm/m^2

Typical Values

r(x, y) for visible light

- Black velvet: ~ 0.01
- Stainless Steal: ~ 0.65
- Flat white wall: ~ 0.80
- Silver plated metal: ~0.90
- Snow: ~0.93

Image Formation Model

- Intensity of monochromatic image at any coordinate (x, y) is called the *gray level* (ℓ)

$$\ell = f(x,y)$$

- ℓ varies from 0 (black) to maximum (white)
- Range: 0 to L-1

Summary

★Single sensor acquisition
★Line sensor acquisition
★Array sensor acquisition
★Model of image formation
★Representation of the Digital Image