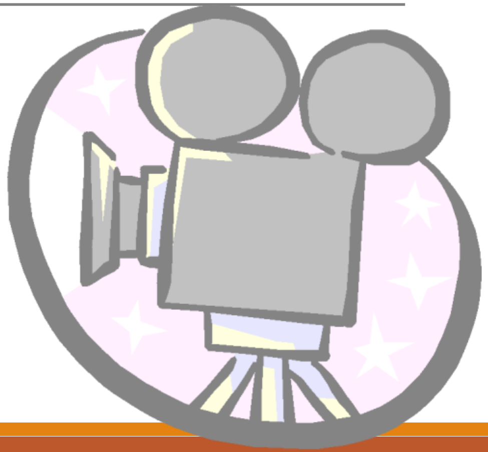
Image Processing

CS-317/CS-341



Outline

- Image Sensing and Acquisition
  - Single Sensor
  - Sensor Strips
  - Sensor Arrays
  - Image Formation Model

Image Sensing and Acquisition

- **The illumination source emits energy which is reflected or absorbed by the element of the scene being imaged.**
  - The wavelength of an EM wave required to see an object must be of the same size as or smaller than the object.
  - The physical properties of the sensor materials also limits the capability of imaging sensors (cf. CCD & CMOS, CCD & IRCCD).

Image Sensing and Acquisition

Radiance

Total amount of energy that flows from the light source (Watts)

Luminance

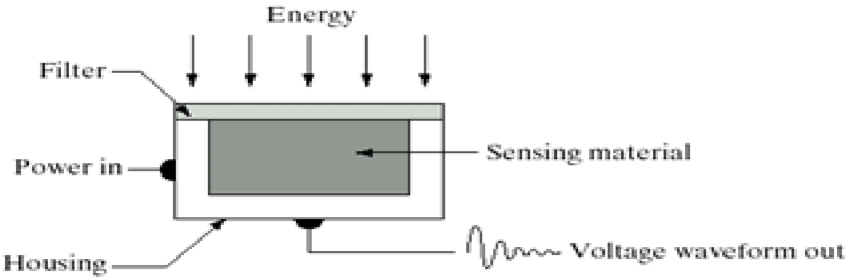
A measure of the amount of energy an observer perceives from a light source (lumens)

Brightness

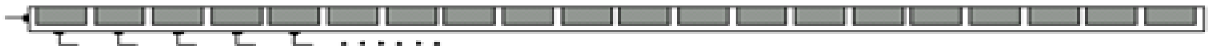
A subjective descriptor of light perception.

Light emitted from a far infrared source have high radiance, but almost no luminance for a sensor in visible band.

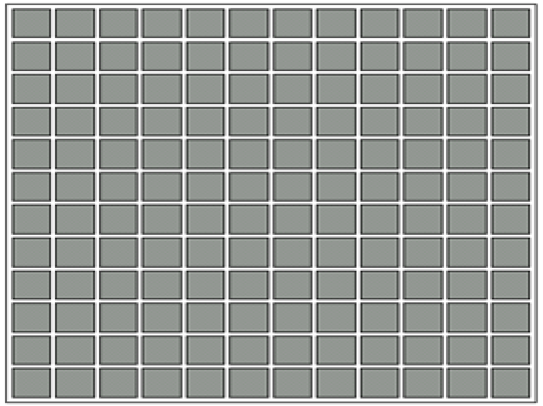
Sensor Arrangement (Spatial Sampling)



Single Imaging Sensor



Line Sensor



Array Sensor

- Incoming energy is transformed into voltage by the combination of input electrical power and sensor material that is responsive to the particular type of energy being detected.
- O/p voltage waveform is the response of the sensor(s), and digital quantity is obtained from each sensor by digitizing its response.

Image Acquisition

- **Using Single Sensor**

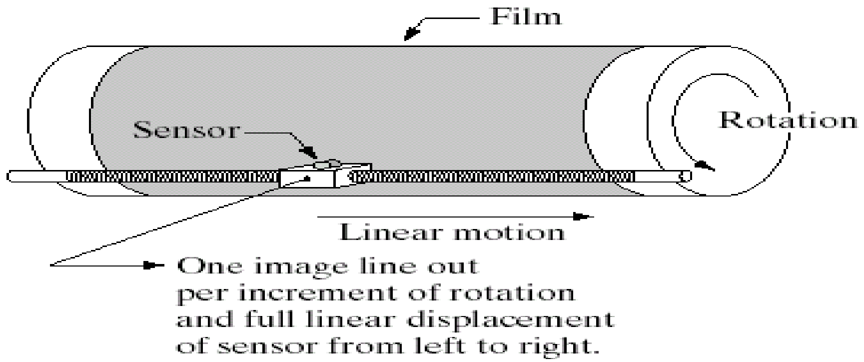


FIGURE 2.13 Combining a single sensor with motion to generate a 2-D image.

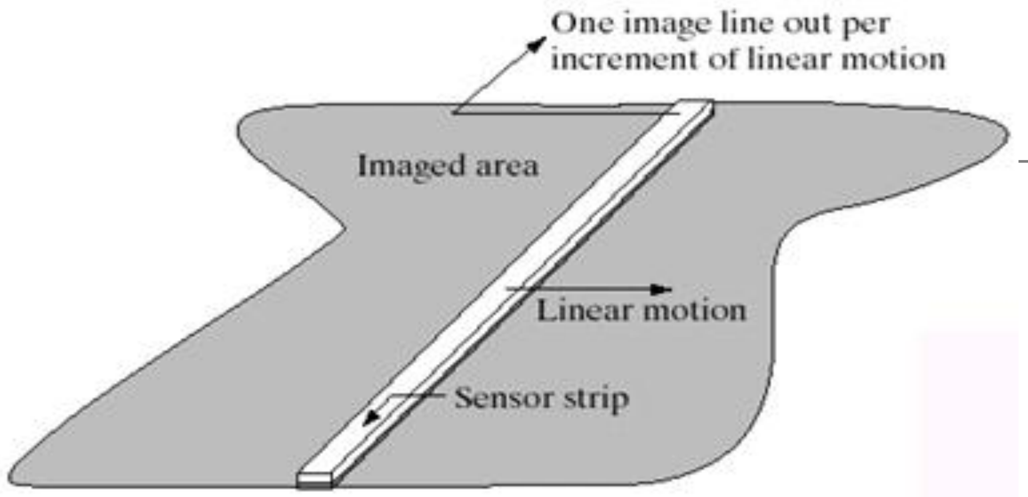
- Relative displacement in both the x- and y- directions between the sensor and the area to be imaged.

-These arrangement needs high precision scanning mechanism.

- Inexpensive but takes lot of time to obtain high-resolution images.

Image Acquisition

- **Using Line Sensor**



-In line arrangement of sensors in the form of a sensor strip.

-Strip provide imaging in one direction and motion perpendicular to the strip provides imaging in other direction.

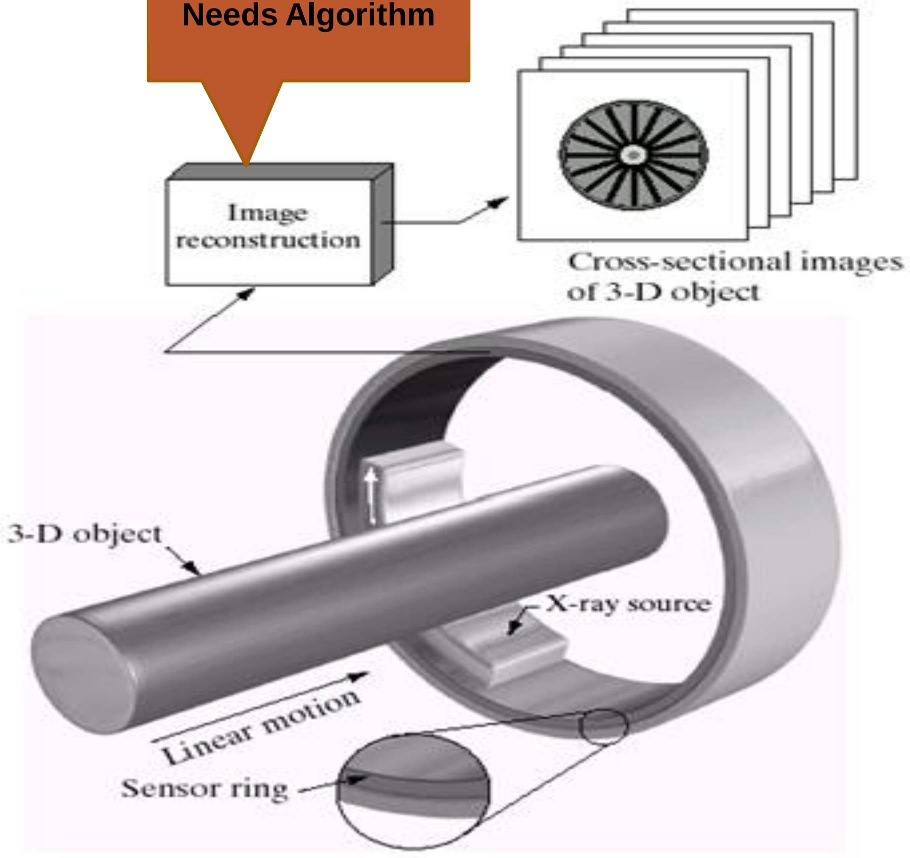
-The imaging strip gives the one line of image at a time, and motion of the strip completes the other dimension.

-Lens or other focusing schemes are used to project the area to be scanned onto the sensor.

Used in most flat bed scanner and airborne imaging application

Image Acquisition

Needs Algorithm



➢ **Line Sensor in Ring Configuration**

- Used in medical and industrial imaging obtain cross-sectional images of 3-D objects.
- Computerized Axial Tomography (CAT):

➢ A rotating X- ray source provides illumination and the portion of the sensors opposite the source collect the X-ray energy that pass through the object.

➢ Output of sensor must be processed by reconstruction algorithm to obtained the meaningful cross sectional images.

➢ A 3-D digital volume consisting of stacked images is generated as the object move in a direction perpendicular to the sensor ring.

➢ MRI, PET imaging modalities is also based on CAT principle only source, sensor, and type of images are different.

Image Acquisition

- **Using Sensor Arrays**

- Sensor are arranged in 2-D array.

- Basic principle is energy from an illumination source is reflected by a scene element is collected and focused by an imaging system onto an image plane, which same as focal plane.
- The sensor array produces the outputs proportional to the integral of light energy received at each sensor.
- Digital and analog circuitry sweep these outputs and convert them to video signal.

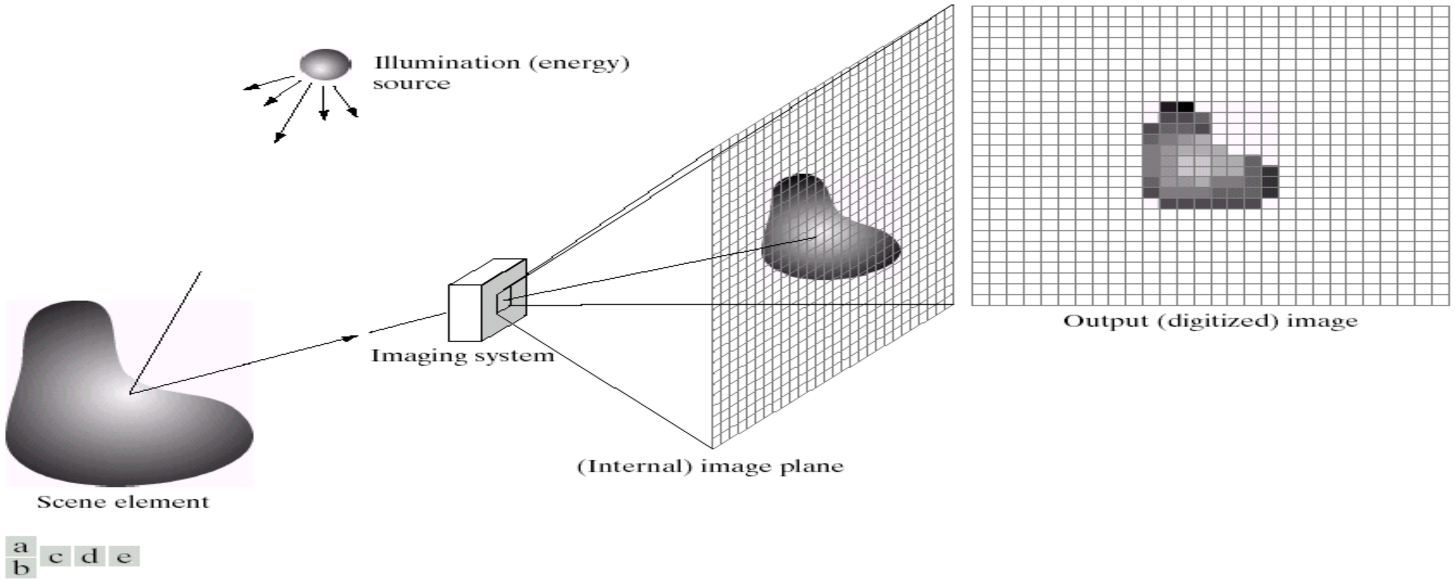
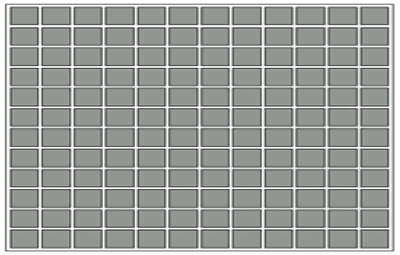


FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.



Array Sensor

Image Formation Model

Light Intensity Function

- **Image** - two dimensional light intensity function, denoted by ***f(x,y)*** , where the value or amplitude of ***f*** at spatial coordinates ***(x,y)*** gives the intensity (brightness) of the image at that point.

Perception of an object : Light reflected from that object

f(x,y) can be characterized by two components

1. The amount of source light incident on the scene being viewed

   Illumination component - *i(x,y)*

2. Amount of light reflected by the objects in the scene

   Reflectance component - *r(x,y)*

$$f(x,y) = i(x,y)r(x,y)$$
$$0 \le i(x,y) < \infty$$
$$0 \le r(x,y) \le 1$$

- Physical meaning of *f* is determined by the source of the image i.e. *i(x,y).*
- *r(x,y)* is determine by the characteristics of the imaged object.

Above expression is also valid for transmission imaging, in this transmissivity is used instead of reflectivity.

Image Formation Model

Light Intensity Function

- Reflectance is bounded by ***0 (total absorption)*** and ***1 (total reflectance)***
- The nature of ***i(x,y)*** is determined by the light source and ***r(x,y)*** is determined by the characteristics of the objects in a scene.

***i(x,y)*:**
Clear Day - 9000 foot-candles
Cloudy day - 1000 foot-candles
Full moon - 0.01 foot candles
commercial office - 100 foot candles

Typical values of ***r(x,y)*:**
Black Velvet - 0.01
Stainless Steel - 0.65
Flat-White wall paint - 0.80
Silver plated metal - 0.90
Snow - 0.93

Grey Level (l) at point (x,y)
- Intensity of monochrome image ***f*** at coordinates ***(x,y)***

Image Formation Model

Light Intensity Function

- we call the intensity of a monochrome image ***f at*** coordinate ***(x,y) the gray level (l) of the image*** at that point.
- thus, ***l*** lies in the range $L_{min} < l < L_{max}$
- L_{min} *is positive and* L_{max} *is finite.*
- gray scale = [L_{min}, L_{max}]
- common practice, shift the interval to [***0, L***]
- ***0 = black , L = white***
- All intermediate values are shades of gray varying from black to white.

Suggested Readings

- **Digital Image Processing by Rafel Gonzalez, Richard Woods, Pearson Education India, 2017.**

- **Fundamental of Digital image processing by A. K Jain, Pearson Education India, 2015.**

Thank you