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Image Sensing & Acquisition.

* Images are created when light or other energy (like X-rays or infrared) interacts with objects by reflecting off or passing through them.
* If the energy reflects, we see an image like a mirror reflection. If it passes through, like X-rays through a body, it helps create an internal image.
* Some systems, like electron microscopes or gamma imaging (SPECT), use special converters to turn this energy into visible images.

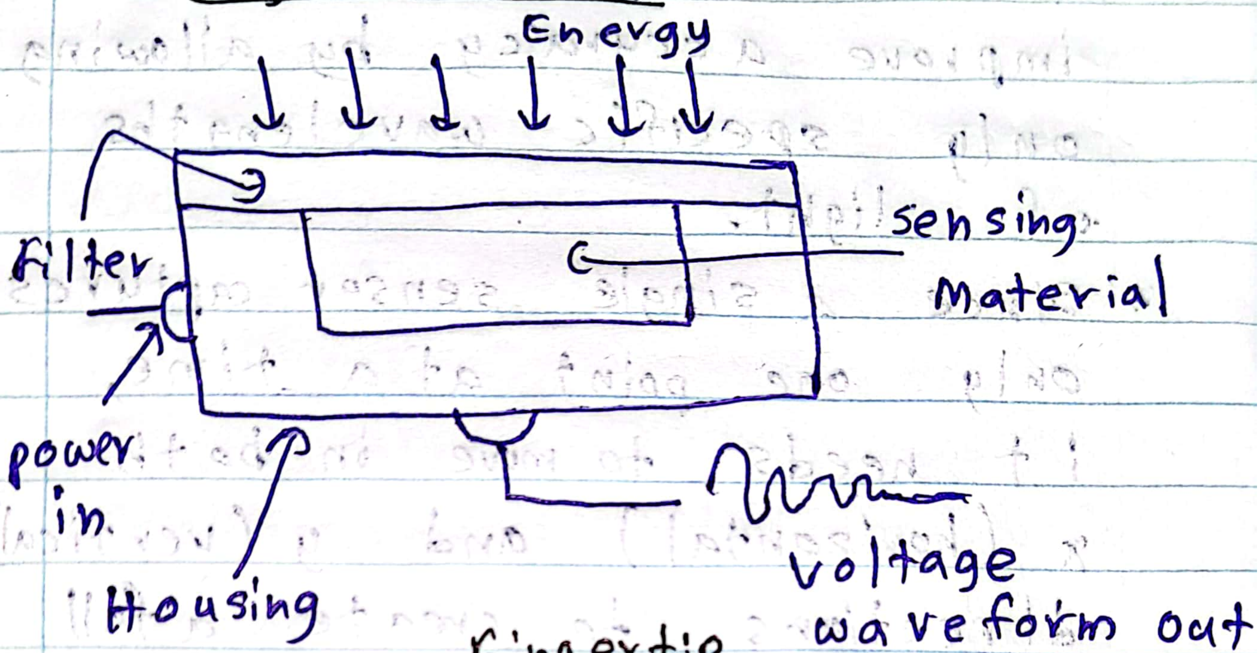
* There are three main types of sensors used to convert light or other energy into digital images.

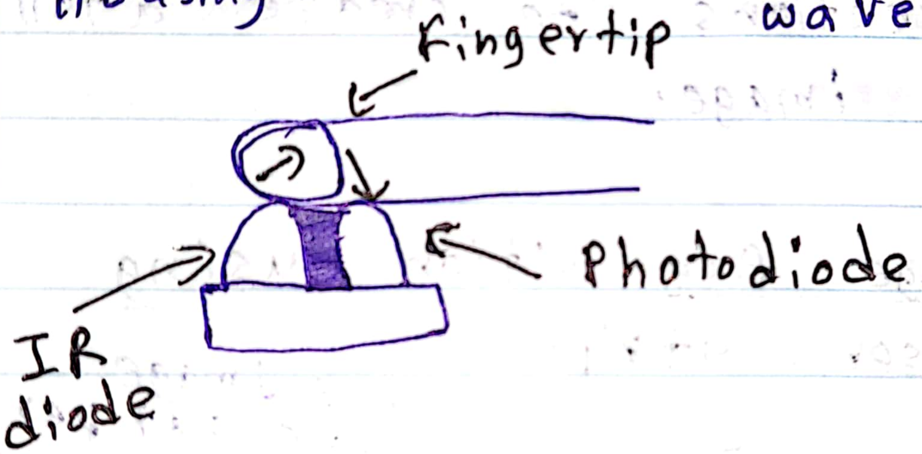
1. single imaging sensor
- Captures one image at a time
2. Line sensor :
- Captures images line by line, useful for scanning.
3. Array Sensor -
- Captures the entire image at once, like a camera sensor.

Sensor Process

* The sensor converts incoming energy into voltage using electrical power and special materials that react to the energy type.
* This voltage signal is then digitized to create a digital image.

* Image acquisition using a single sensor

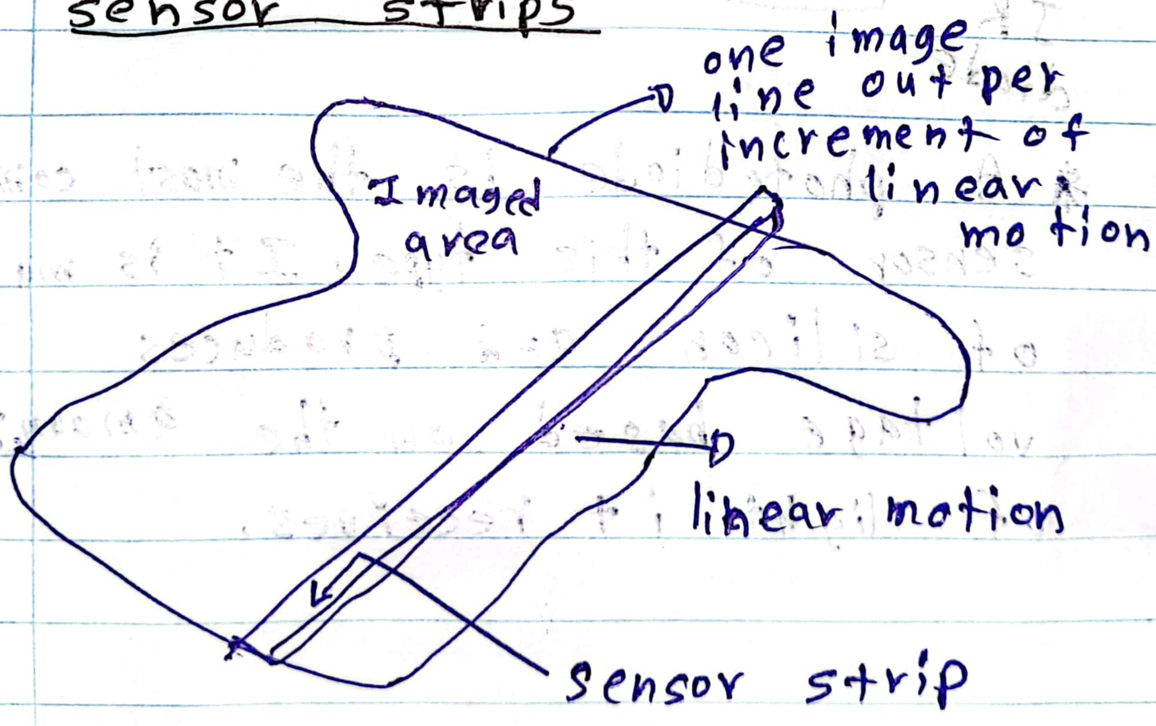




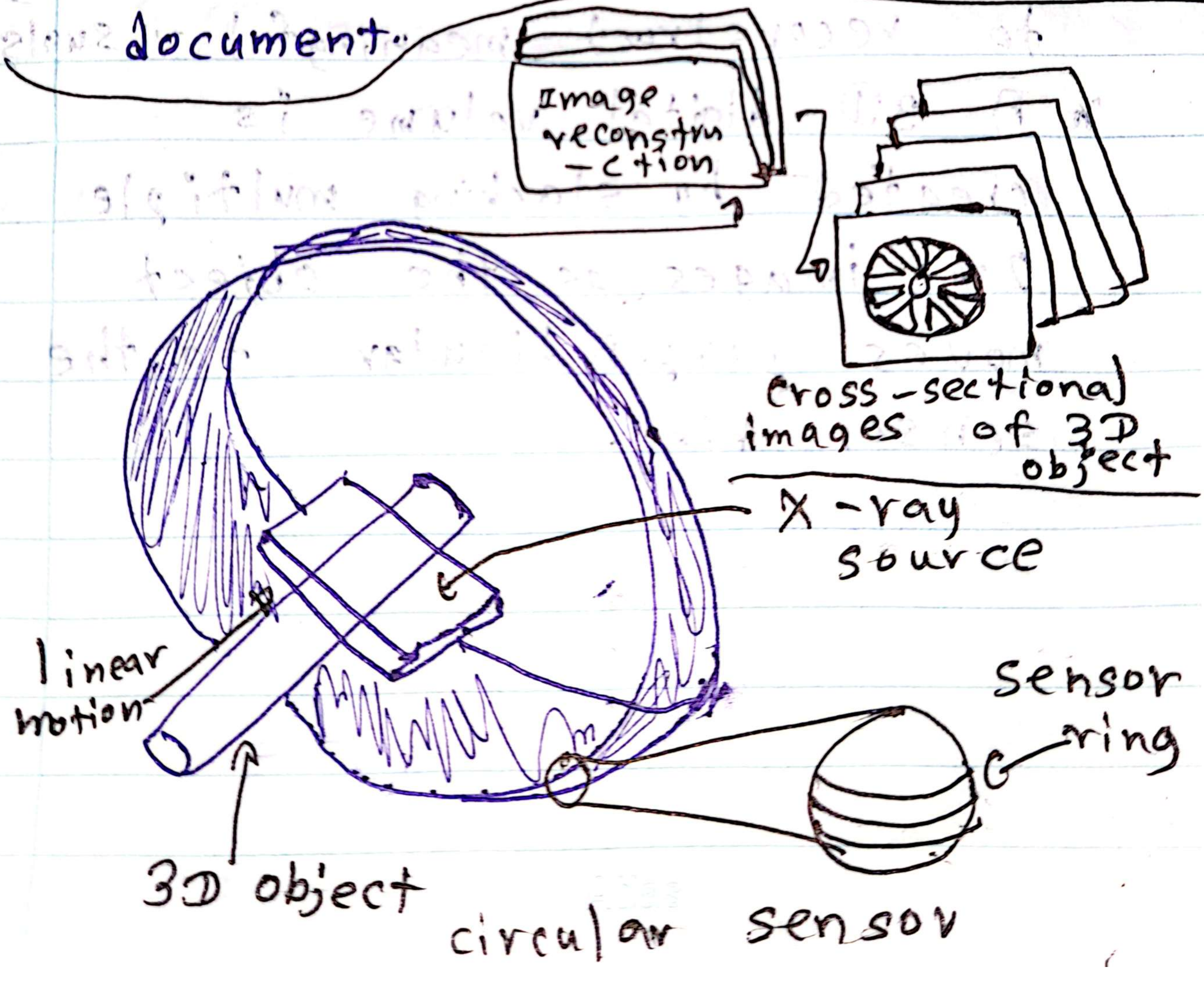
* A photodiode is the most common sensor of this type. It is made of silicon and produces voltage based on the amount of light it receives.

* A filter can be placed in front of the sensor to improve accuracy by allowing only specific wavelengths of light.
* Since a single sensor captures only one point at a time, it needs to move in both x (horizontal) and y (vertical) directions to create a full 2D image.

* <u>Image Acquisition using sensor strips</u>



* A sensor strip captures images in one direction (like a single row of pixels)
* To create a full image, the object, or sensor must move in the perpendicular (ලම්බ) direction
* This method is commonly used in flatbed scanners, where the scanning head moves to capture the entire document.



* Sensor strips in a Ring Configuration

* Used in medical and industrial imaging to capture cross-sectional (slice-by-slice) images of 3D objects.
* Examples: CAT (CT scans), MRI, and PET scans use this method.
* Unlike regular scanning, these images require complex processing to reconstruct meaningful visuals
* A 3D digital volume is created by stacking multiple 2D images as the object moves perpendicular to the sensor ring.

* Image Acquisition using Sensor Arrays.

* Many electromagnetic and ultrasonic sensors are arranged in arrays for imaging.
* This method is commonly used in digital cameras
* Each sensor in the array captures total light energy falling on it, converting it into a digital image.
* key advantage: A 2D sensor array captures a complete image instantly without needing movement.

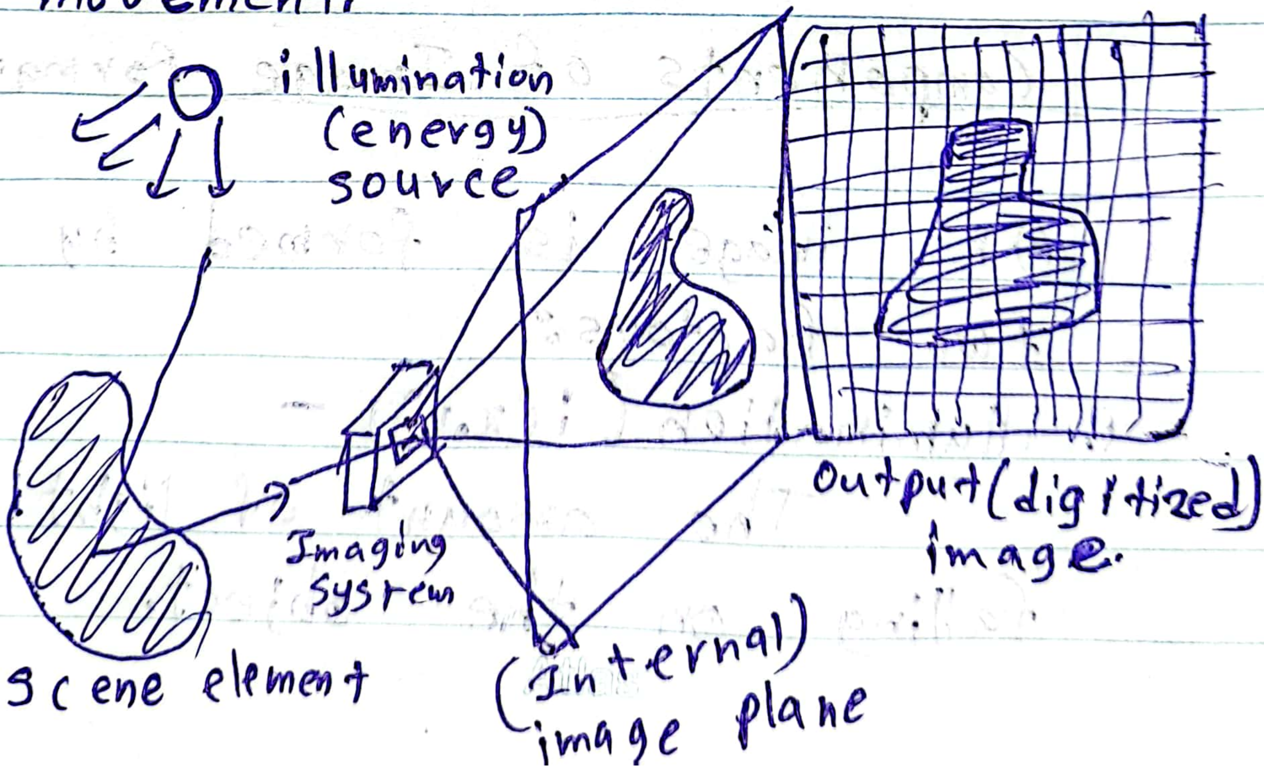


Image Formation Model

* An image is represented as 2D function: $f(x,y)$, where x and y are coordinates and
* $f(x,y)$ gives the brightness at that point.
* The brightness value depends on the energy source, such as light or electromagnetic waves.
* since light has positive energy, the function must be non-zero and finite $(0 < f(x,y) < \infty)$.

Components of Image Formation

An image is formed by two factors:

1. illumination $(i(x,y))$ – The amount of light falling on the object.

CamScanner

2. Reflectance ($r(x,y)$) – The amount of light reflected from the object.

These combine as:

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

* illumination ($i(x,y)$) is always positive ($0 < i(x,y) < \infty$)
* Reflectance ($r(x,y)$) is between 0 (total absorption, black) and 1 (total reflection, white)

Gray Levels and Grayscale

* The brightness at any point is called its gray level (l), which lies within a range [L_{min}, L_{max}], caled the gray scale.
* In practice, this range is mapped to $[0, L-1]$, where:

- 0 = black
- L-1 = white.
- Intermediate values = shades of gray.