SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECE351 – IMAGE PROCESSING AND COMPUTER VISION

III B.E. ECE / V SEMESTER

UNIT 5 – COMPUTER VISION

TOPIC – Introduction to Computer Vision - Image formation and Processing

Introduction

As humans, we perceive the three-dimensional structure of the world around us with apparent ease.
Imagine looking at a flower vase.
We can effortlessly perceive each petal's shape and translucency and can separate the flowers from the background

The human visual system has no problem interpreting the subtle variations in translucency and shading in this photograph and correctly segmenting the object from its background

Computer vision aims at giving computers the ability to understand the environment as we do.
It focuses on looking at the world through multiple images or videos and reconstructing properties like the shape of objects, intensity, color distributions, etc.

Recent advancements in the field of deep learning are enabling computer vision methods to understand and automate tasks that the human visual system can do

Image Formation

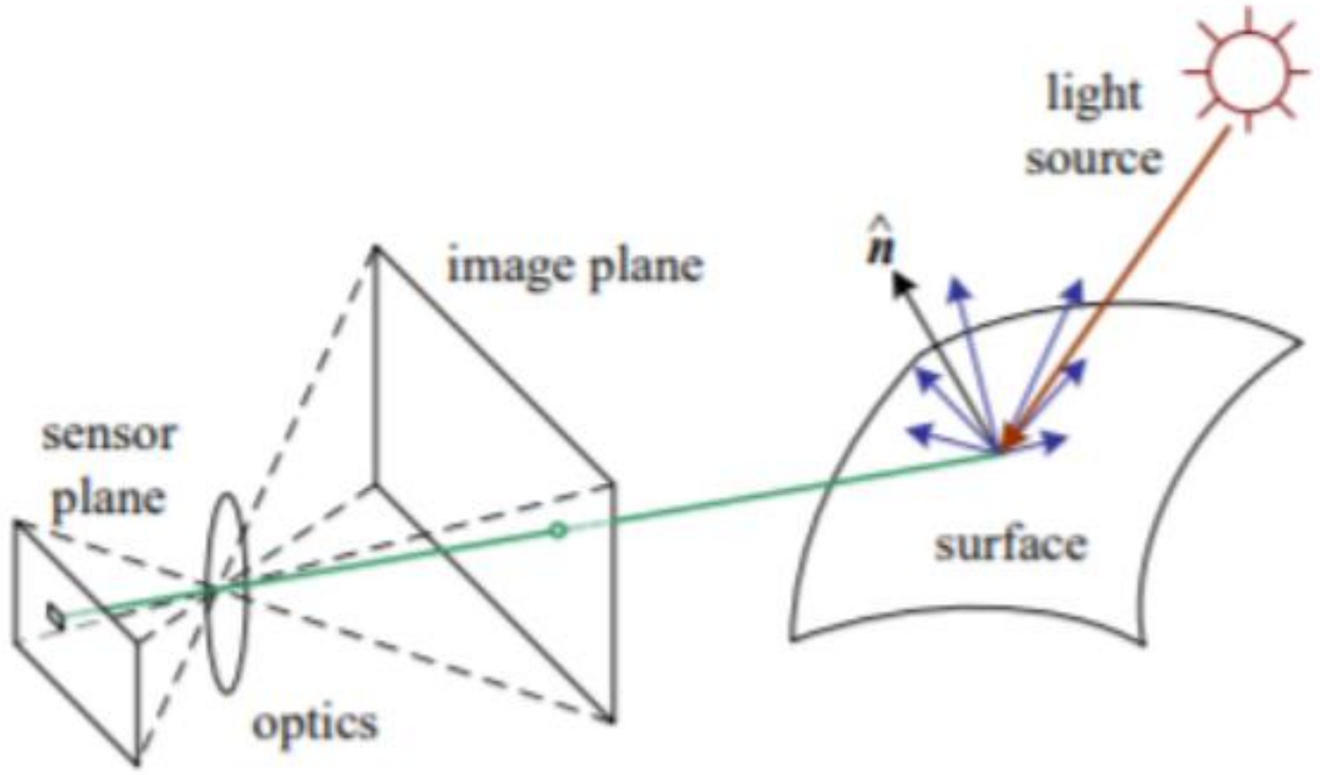
In modeling any image formation process, geometric primitives and transformations are crucial to project 3-D geometric features into 2-D features.

However, apart from geometric features, image formation also depends on discrete color and intensity values. It needs to know the lighting of the environment, camera optics, sensor properties, etc.

Therefore, while talking about image formation in Computer Vision, the article will be focusing on **photometric image formation.**

Photographic Image Formation

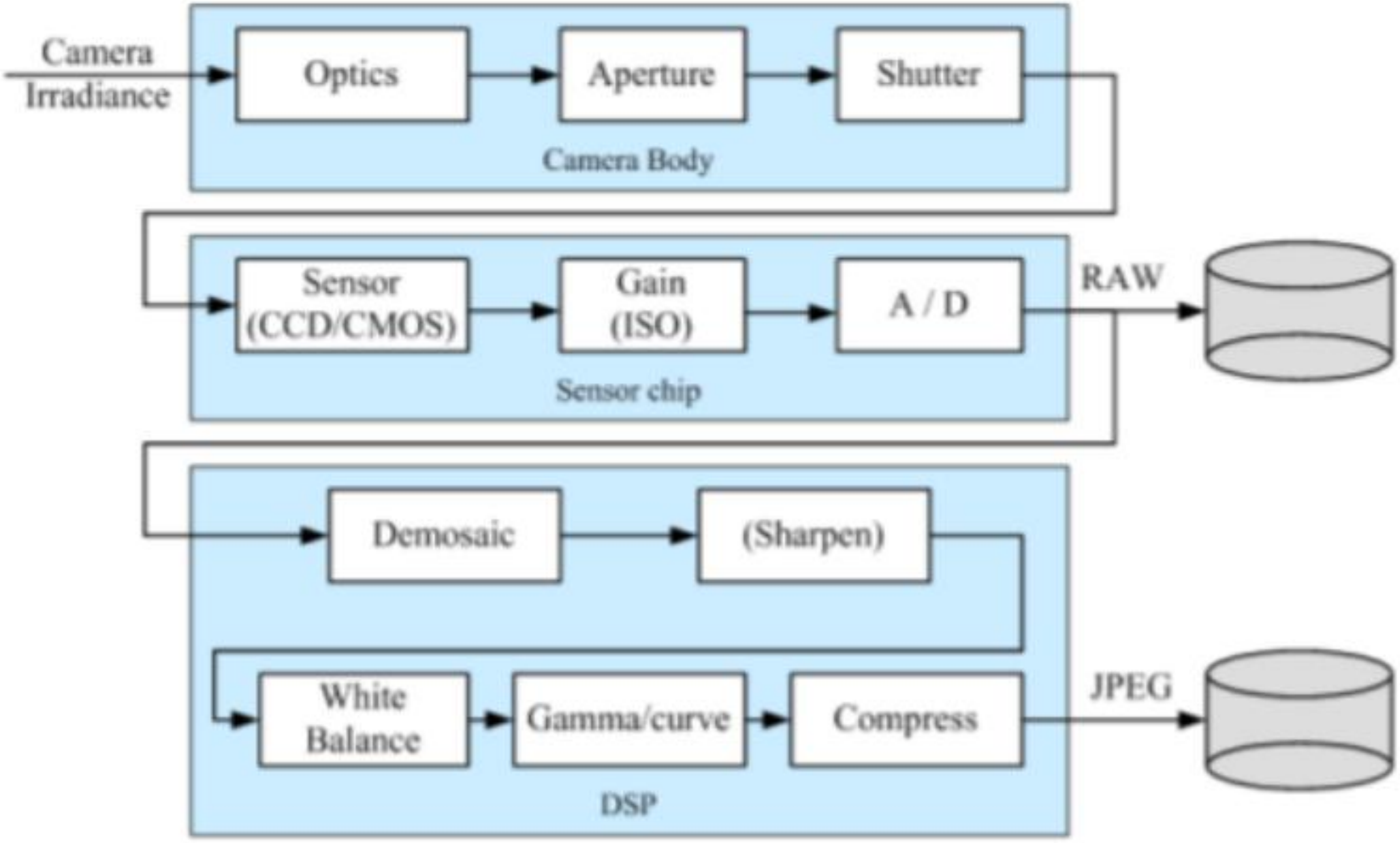
The light from a source is reflected on a particular surface.
A part of that reflected light goes through an image plane that reaches a sensor plane via optics.



Some factors that affect image formation are:

- The strength and direction of the light emitted from the source.
- The material and surface geometry along with other nearby surfaces.
- Sensor Capture properties

Image sensing Pipeline (The digital camera)



CCD vs CMOS

The camera sensor can be CCD or CMOS.
In charged coupled device (CCD). A charge is generated at each sensing element and this photogenerated charge is moved from pixel to pixel and is converted into a voltage at the output node.
Then an analog to digital converter (ADC) converts the value of each pixel to a digital value.

The complementary metal-oxide-semiconductor (CMOS) sensors work by converting charge to voltage inside **each** element as opposed to CCD which accumulates the charge.
CMOS signal is digital and therefore does not need ADC.
CMOS is widely used in cameras in the current times.

Properties of Digital Image Sensor

Shutter Speed: It controls the amount of light reaching the sensor
Sampling Pitch: It defines the physical space between adjacent sensor cells on the imaging chip.
Fill Factor: It is the ratio of active sensing area size with respect to the theoretically available sensing area (product of horizontal and vertical sampling pitches)
Chip Size: Entire size of the chip
Sensor Noise: Noise from various sources in the sensing process
Resolution: It tells you how many bits are specified for each pixel.
Post-processing: Digital image enhancement methods used before compression and storage.

Image Representation

Image **as** a matrix

The simplest way to represent the image is in the form of a matrix.

It is commonly seen that people use up to a byte to represent every pixel of the image. This means that values between 0 to 255 represent the intensity for each pixel in the image where 0 is black and 255 is white.

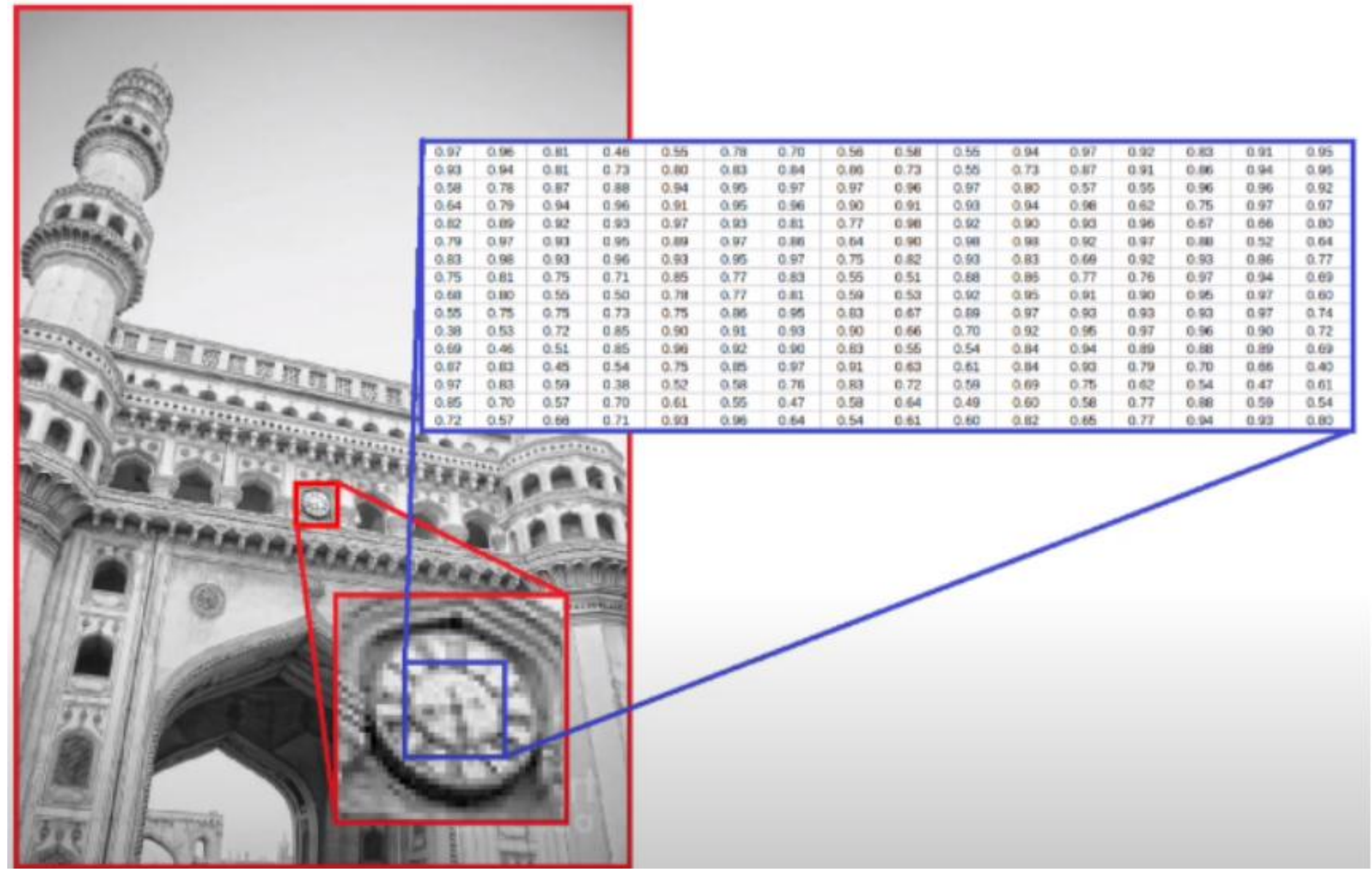


Image as a function

An image can also be represented as a function. An image (grayscale) can be thought of as a function that takes in a pixel coordinate and gives the intensity at that pixel.

It can be written as function $f: \mathbb{R}^2 \rightarrow \mathbb{R}$ that outputs the intensity at any input point (x,y). The value of intensity can be between 0 to 255 or 0 to 1 if values are normalized.

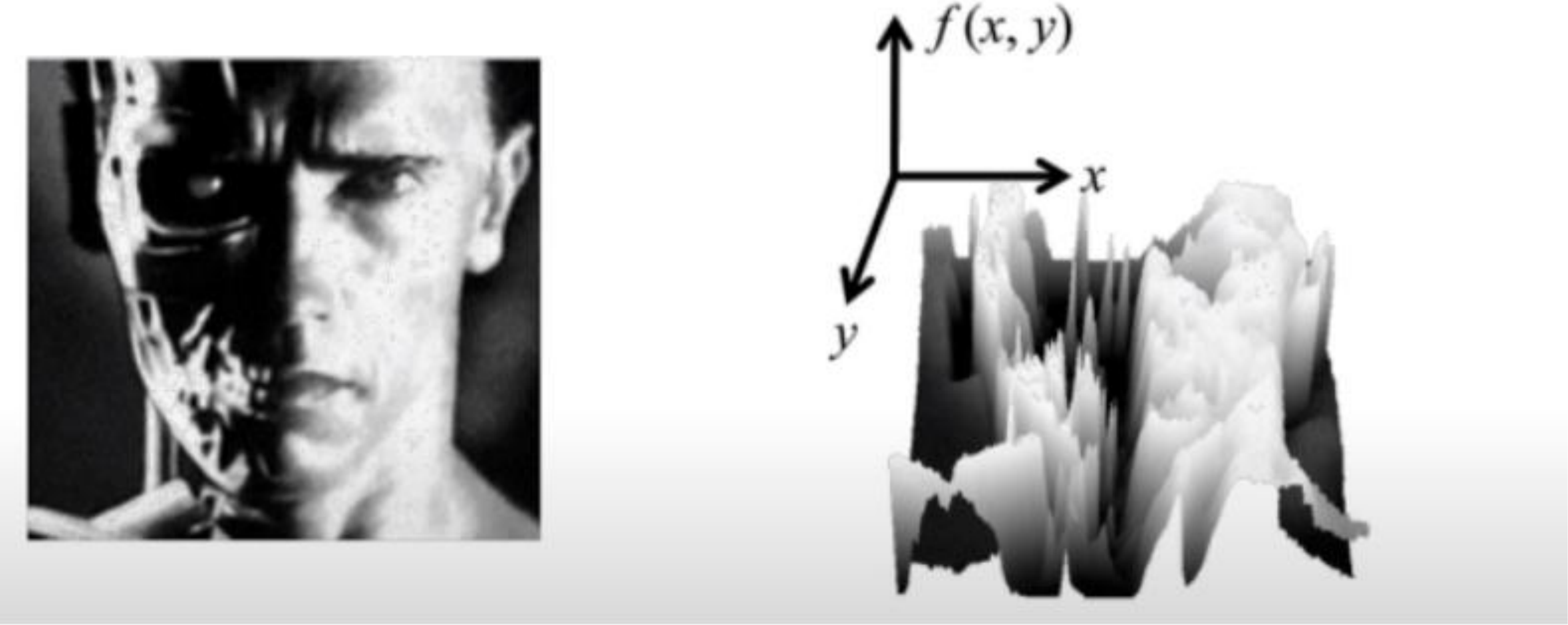


Image Transformation

Images can be transformed when they are looked upon as functions. A change in the function can result in changes in the pixel values of the image.

f(x,y)

f(x,y) + 20

f(x,y)

f(-x,y)

Lightening the image

Change in the function to flip the image around the vertical axis

Image Processing Operations

- Point Operations
- Local Operations
- Global Operations

Point Operation

Output value depends only on the input value at that particular coordinate

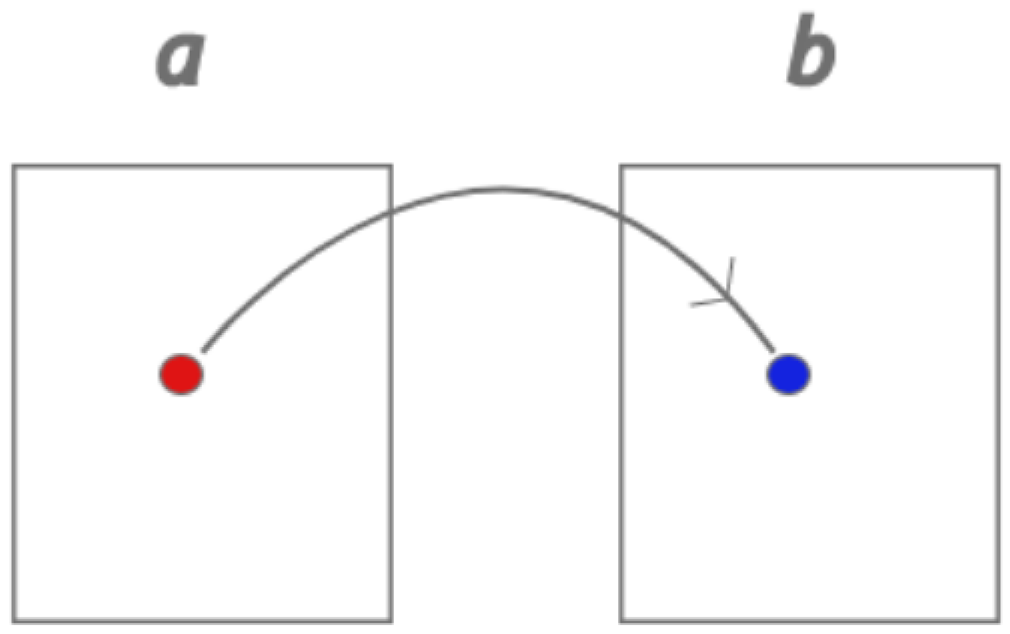


Image Processing Operations

Local Operation

Output value is dependent on the input value and its neighbors

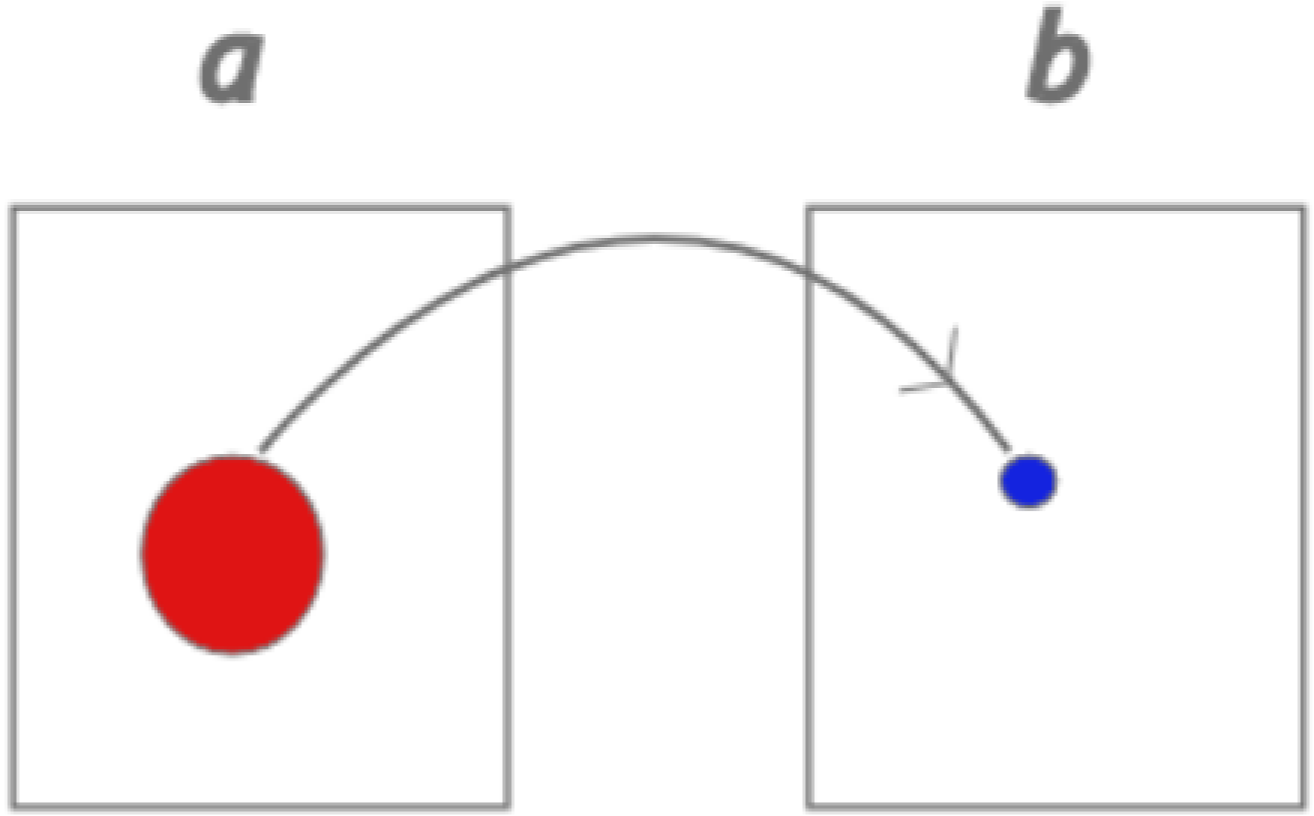
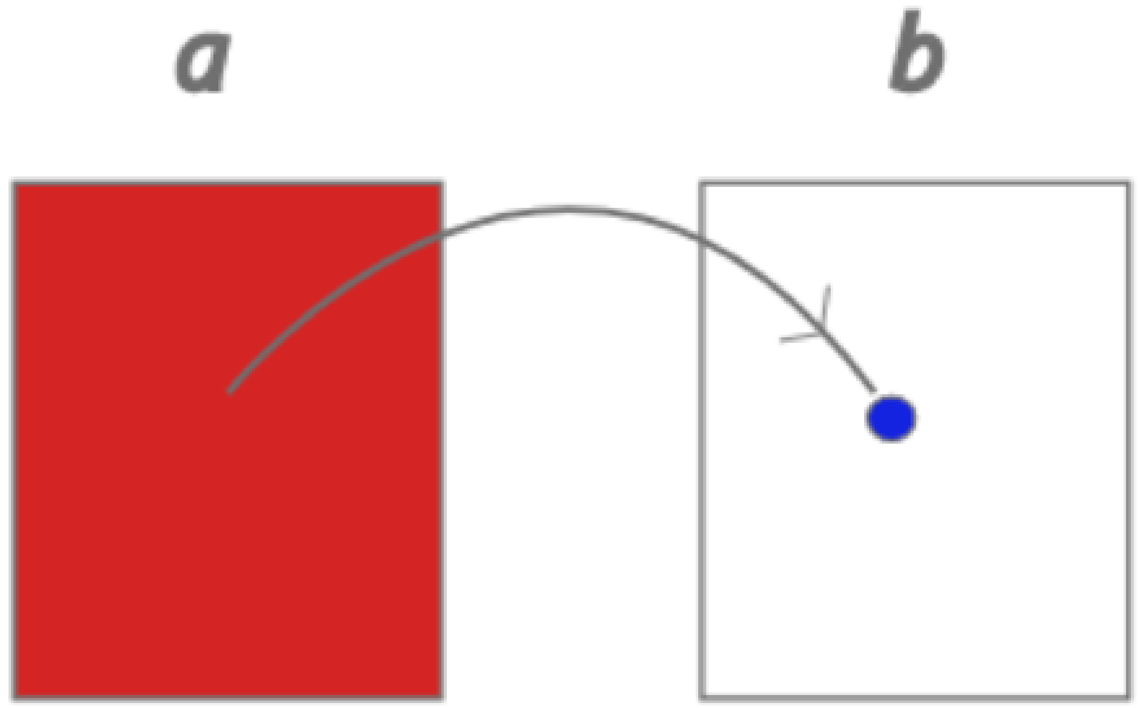


Image Processing Operations

Global Operation

Output pixel is dependent on the entire input image



Thank you!