DIGITAL IMAGE PROCESSING

LECTURE-1

INTRODUCTION TO DIGITAL IMAGE PROCESSING

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DIGITAL IMAGE PROCESSING
INTRODUCTION

- *An **image** may be defined as a two-dimensional function, where x and y are **spatial** (plane) coordinates.*
- *The **amplitude** of f at any pair of coordinates (x, y) is called the **intensity** or **gray level** of the image at that point.*
- *When x, y, and the intensity values of f are all **finite, discrete quantities**, we call the image a **digital image**.*
- *The field of **digital image processing** refers to **processing** digital images by means of a digital computer.*

DIGITAL IMAGE PROCESSING
ELEMENTS OF IMAGE PROCESSING

- *Digital image is composed of a **finite number of elements**, each of which has a particular location and value.*
- *These elements are called **picture elements, image elements, pels, and pixels**.*
- ***Pixel** is the term used most widely to denote the elements of a digital image.*

DIGITAL IMAGE PROCESSING

IMAGE PROCESSING vs *COMPUTER VISION* vs *IMAGE ANALYSIS*

IMAGE PROCESSING: both the input and output of a process are images.

COMPUTER VISION: *use computers to emulate human vision, including learning and being able to make inferences and take actions based on visual inputs.(Branch of Artificial Intelligence)*

IMAGE ANALYSIS: *(also called image understanding) is in between image processing and computer vision.*

DIGITAL IMAGE PROCESSING

IMAGE PROCESSING vs *COMPUTER VISION vs IMAGE ANALYSIS*

Three types of computerized processes

low-, mid-, and high-level processes.

Low-level processes involve primitive operations such as image preprocessing to reduce

noise, contrast enhancement, and image sharpening.

A **low-level process** is characterized by the fact that both its inputs and outputs are images.

DIGITAL IMAGE PROCESSING

IMAGE PROCESSING vs *COMPUTER VISION vs IMAGE ANALYSIS*

Mid-level processing on images involves tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects.

A **mid-level process** is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images (e.g., edges, contours, and the identity of individual objects).

DIGITAL IMAGE PROCESSING

IMAGE PROCESSING vs *COMPUTER VISION vs IMAGE ANALYSIS*

Higher-level processing involves "making sense" of an ensemble of recognized objects, as in image analysis.

Higher-level processing perform the cognitive functions normally associated with vision.

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NEW IMAGE PROCESSING METHODS

1-Image restoration *is an area that also deals with improving the appearance of an image.*

2-Color image processing *is an area that covers a number of fundamental concepts in color models and basic color processing in a digital domain. Color is used as the basis for extracting features of interest in an image*

3-Wavelets *is used for image data compression and for pyramidal representation, in which images are subdivided successively into smaller regions.*

4-Compression *deals with techniques for reducing the storage required to save an image, or the bandwidth required to transmit it. such as the jpg file extension used in the JPEG (Joint Photographic Experts Group) image compression standard.*

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NEW IMAGE PROCESSING METHODS

<u>5-Morphological processing</u> deals with tools for extracting image components that are useful in the representation and description of shape.

<u>6-Segmentation</u> *procedures partition an image into its constituent parts or objects.*

<u>7-Representation and description</u> *follow the output of a segmentation stage, which usually is raw pixel data, constituting the boundary of a region.*

<u>8-Recognition</u> *is the process that assigns a label (e.g., "vehicle") to an object based on its descriptors.*

DIGITAL IMAGE PROCESSING
COMPONENTS OF IMAGE PROCESSING

Sensor physical device that is sensitive to the energy radiated by the object we wish to image.

Digitizer is a device for *converting the output of the physical sensing device into digital form.*

For instance, in a digital video camera, the sensors produce an electrical output proportional to light intensity. The digitizer converts these outputs to digital data.

DIGITAL IMAGE PROCESSING

IMAGE MODEL

1. Image as a Matrix of Pixels

The most basic image model in digital image processing is the **discrete image model**, where an image is represented as a matrix (or grid) of pixel values. Each pixel corresponds to a point in the image, and its value encodes the color or intensity at that location.

- **Grayscale Image Model**: In a grayscale image, each pixel has a single intensity value (brightness) between 0 (black) and 255 (white), where the intermediate values represent different shades of gray.
- **Color Image Model**: In a color image, each pixel has multiple components representing the color, typically red, green, and blue (RGB). Each color channel is a separate grayscale image, and the combination of the three channels forms a color image.

DIGITAL IMAGE PROCESSING

IMAGE MODEL

2. Geometric Models

Geometric models describe how the image is spatially structured and can include transformations, such as scaling, rotation, and translation. These models are important for tasks like image registration, alignment, and geometric corrections.

3. Statistical Models

Statistical image models represent an image as a set of random variables, where each pixel (or group of pixels) is treated probabilistically. These models help in noise reduction, texture analysis, and image restoration.

Common statistical image models include:

- **Gaussian Models**: Used to model smooth variations in pixel intensities, often assuming that pixel values follow a normal distribution.
- **Markov Random Fields**: A model that takes into account the relationship between neighboring pixels for texture analysis and segmentation tasks.

IMAGE MODEL

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4. Physical Models

These models simulate the physical properties of how images are formed, such as the interaction between light, objects, and the camera. They are used in applications like 3D reconstruction and medical imaging, where physical properties of the object being imaged need to be taken into account.

5. Transform Models

These models transform the image data into a different domain (e.g., frequency domain) for specific tasks such as image compression, enhancement, or filtering. Some examples include:

- **Fourier Transform Model**: Represents an image in terms of its frequency components, helping in tasks like image filtering and compression.
- **Wavelet Transform Model**: Used for multi-resolution analysis, allowing both spatial and frequency information to be captured simultaneously.

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IMAGE

6. Histogram Models

In this model, the image is represented in terms of its pixel intensity distribution. The histogram is a graphical representation of the frequency of different intensity levels. Histogram models are often used for contrast enhancement, thresholding, and equalization.

7. Texture Models

Texture models describe the repetitive patterns in an image. They are used in applications such as texture analysis, classification, and segmentation. Texture features might be captured using statistical measures, frequency-based methods (e.g., Gabor filters), or structural approaches.

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IMAGE MODEL

8. Segmentation Models

These models aim to partition an image into meaningful regions based on criteria such as intensity, color, or texture. Common segmentation models include:

- **Thresholding models**: Segment images based on intensity levels.
- **Region-growing models**: Segment regions that are similar according to certain criteria.
- **Edge-detection models**: Use gradients or derivatives to find boundaries between regions.

DIGITAL IMAGE PROCESSING

IMAGE SAMPLING AND QUANTIZATION

To create a digital image, we need to convert the continuous sensed data into digital form.This involves two processes: ***sampling*** and ***quantization***.

To convert an image to digital form, we have to **sample** the *function in both coordinates and in amplitude.*

Digitizing *the coordinate values is called* ***sampling***.

Digitizing the amplitude values is called ***quantization***.

DIGITAL IMAGE PROCESSING

IMAGE SAMPLING AND QUANTIZATION

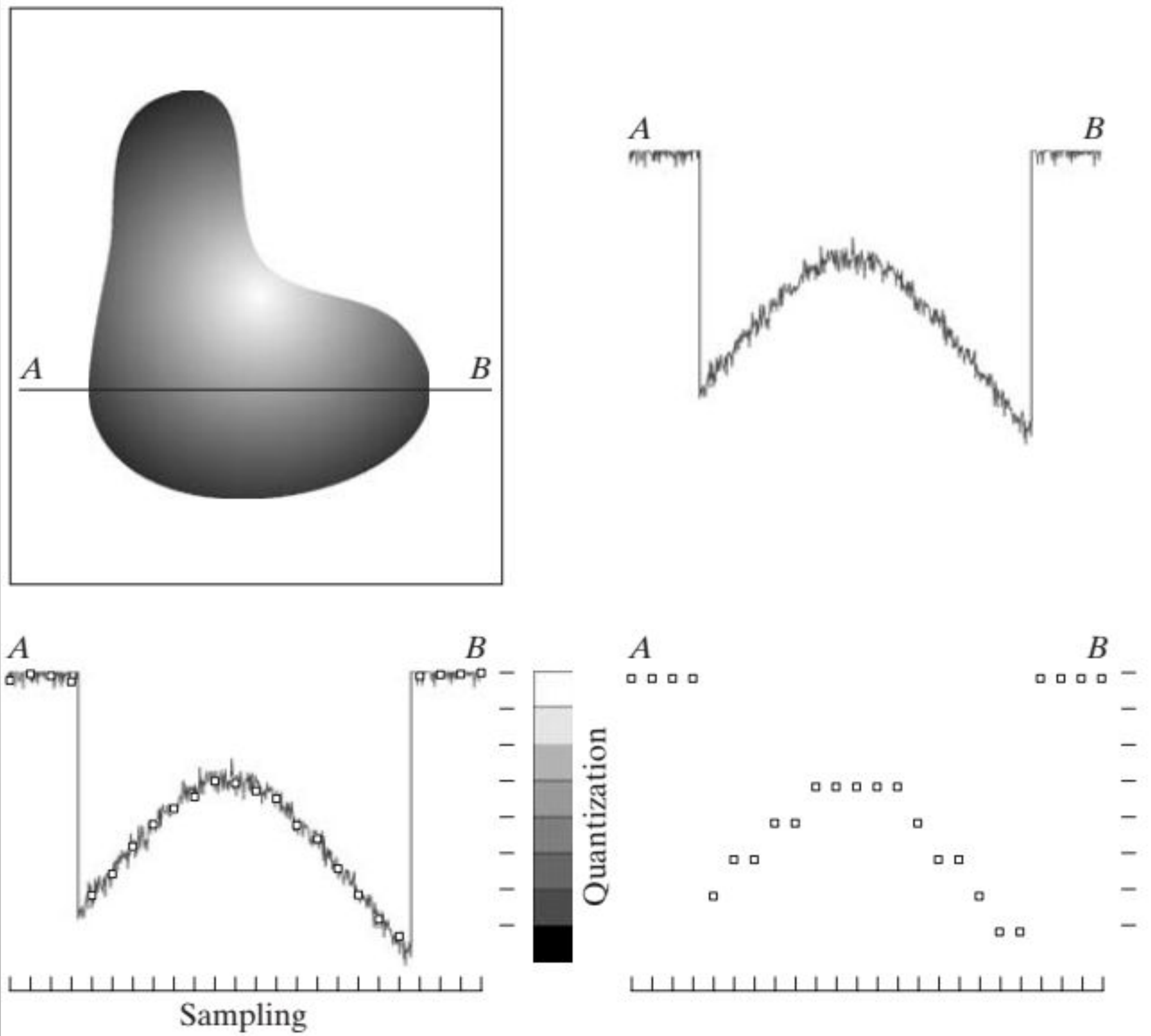
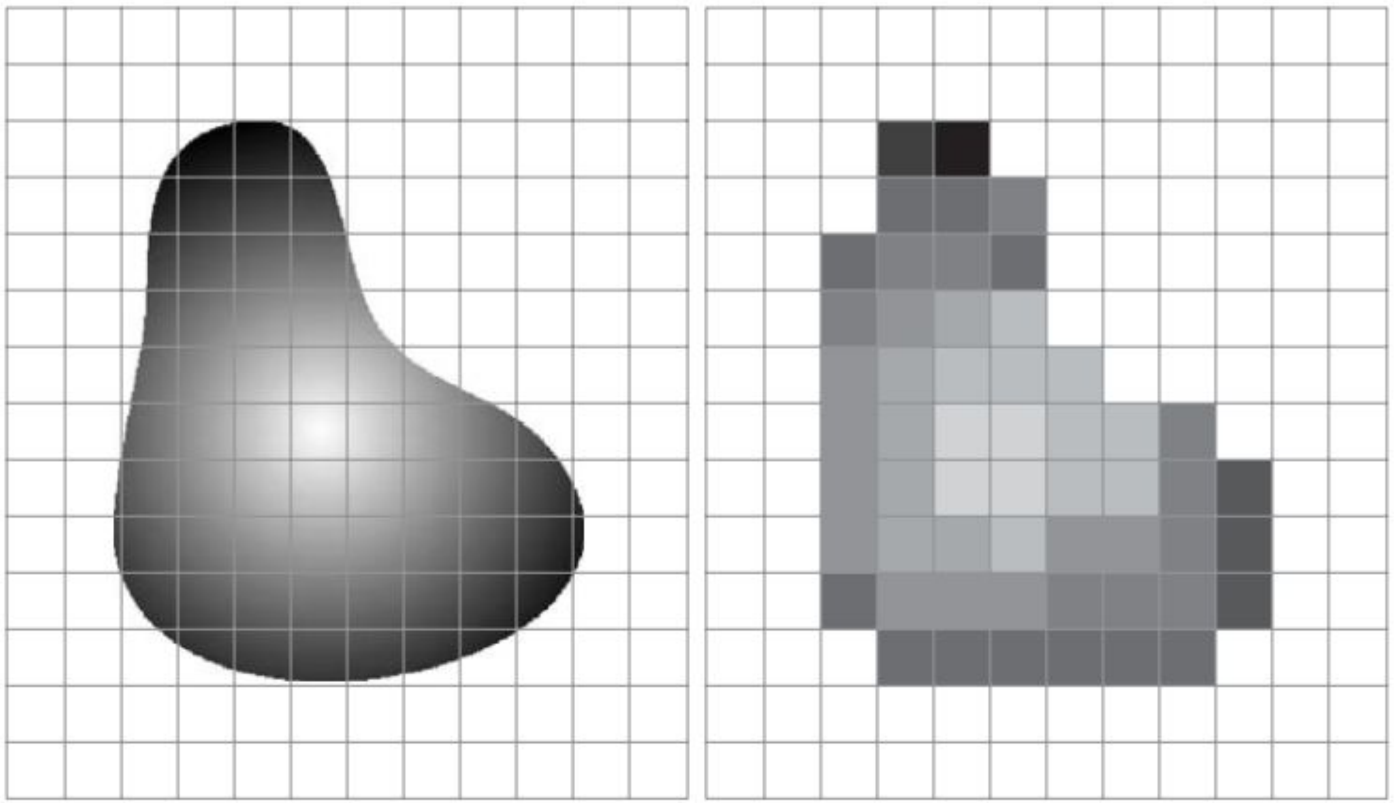


FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from *A* to *B* in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

DIGITAL IMAGE PROCESSING

IMAGE SAMPLING AND QUANTIZATION

Figure 2.17(a) shows a continuous image projected onto the plane of an array sensor.
Figure 2.17(b) shows the image after sampling and quantization. Clearly, the quality of a digital image is determined to a large degree by the number of samples and discrete intensity levels used in sampling and quantization.



a b

FIGURE 2.17 (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

DIGITAL IMAGE PROCESSING

RELATIONSHIPS BETWEEN PIXELS

Neighbors of a Pixel

This set of pixels, called the 4-*neighbors* of p, is denoted by $N_4(p)$. Each pixel is a unit distance from (x, y), and some of the neighbor locations of p lie outside the digital image if (x, y) is on the border of the image.

The four *diagonal* neighbors of p have coordinates

$$(x + 1, y + 1), (x + 1, y - 1), (x - 1, y + 1), (x - 1, y - 1)$$

and are denoted by $N_D(p)$. These points, together with the 4-neighbors, are called the 8-*neighbors* of p, denoted by $N_8(p)$. As before, some of the neighbor locations in $N_D(p)$ and $N_8(p)$ fall outside the image if (x, y) is on the border of the image.

THANK YOU