Friedrich-Alexander-Universität
Technische Fakultät

Lecture 2, Part 1

Image & Light

Computer Vision
Summer Semester 2023

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Why is Vision Difficult?

- Inverse Problem!

Real World Image

- Shape
- Shading
- Orientation
- Reflectance
- 3D model
- Etc…

Why is Vision Difficult?

- Inherently ill-posed

Real World Image

(Known)

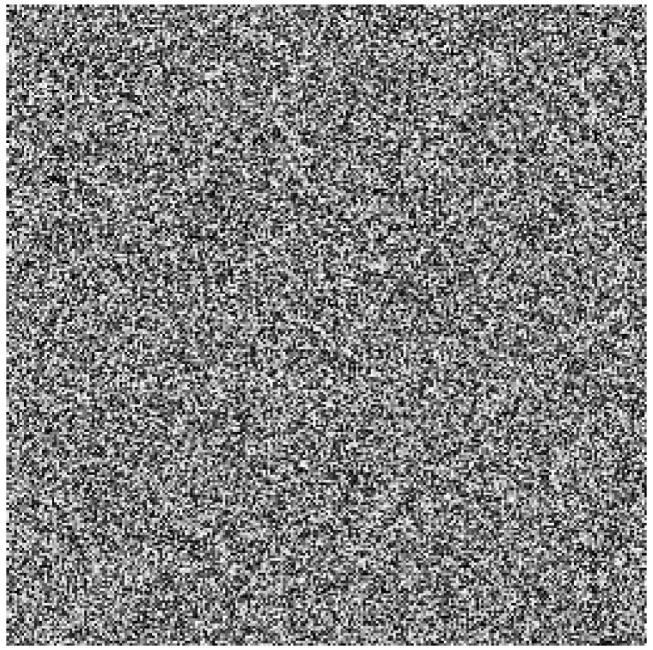
- Shape
- Shading
- Orientation
- Reflectance
- 3D model
- Etc…

(UnKnowns)

What is an Image?

```
>> I = rand(256,256);
```

- Which values does it take?
- How many values can it take?
- Is it an image?

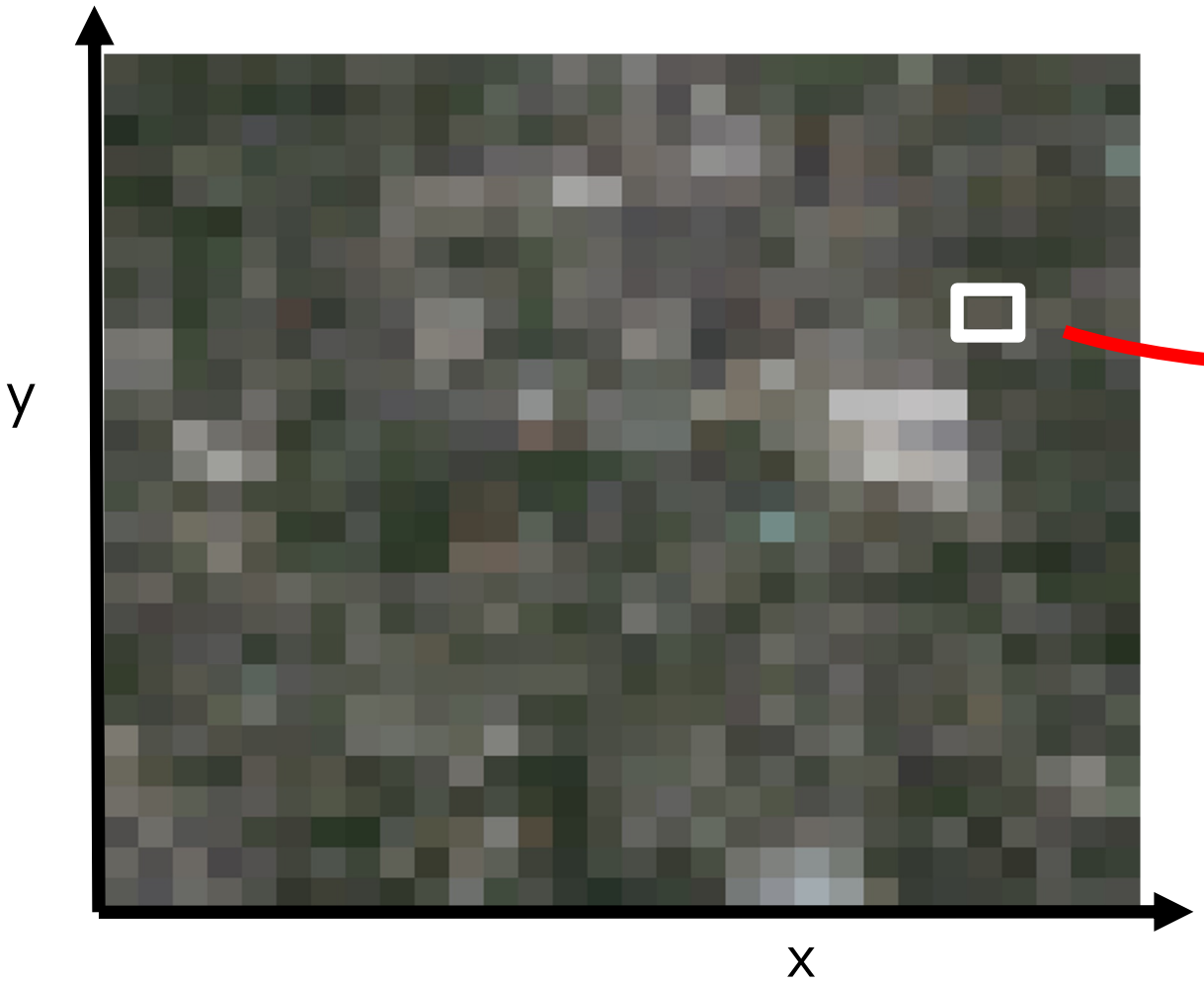


Dimensionality of an Image

- 256×256 pixels @ 8bit = $\{256 \text{ values}\}^{65,536}$
  - A staggering amount of possible images
  - High dimensionality (i.e., degrees of freedom) poses a challenge

- Computer vision → making sense of an extremely high-dimensional space.
  - Subspace of 'natural' images.
  - Deriving low-dimensional, explainable models.

What is each part of an image?



Pixel → picture element

I(x,y) **138**

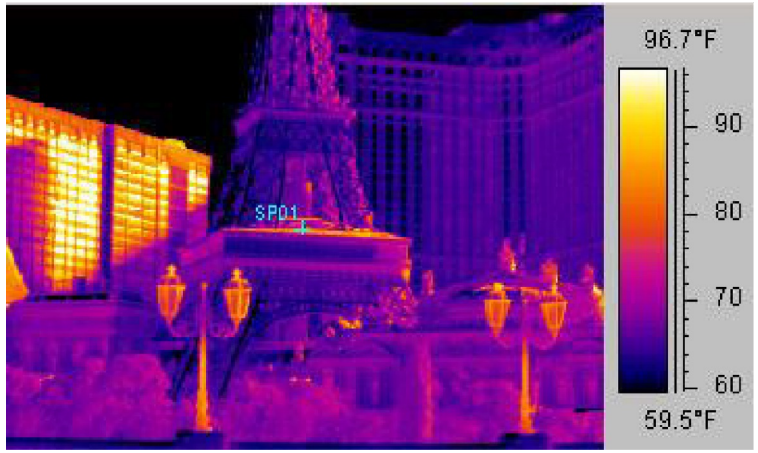
Image as a 2D sampling of signal

- **Signal:** function depending on some variable with physical meaning
- **Image:** sampling of that function.
  - 2 variables: xy coordinates
  - 3 variables: xy + time (*video*)
  - 'Brightness' is the value of the function for visible light
- Other physical values too: temperature, pressure, depth …

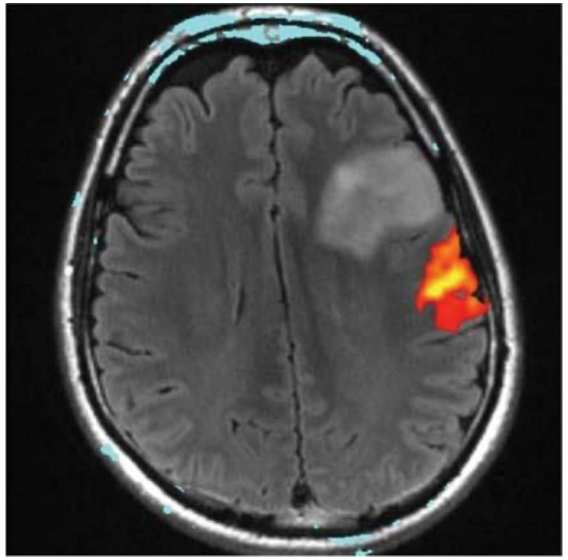
Example 2D Images

(a) Natural Image

(c) Ultra Sound Image



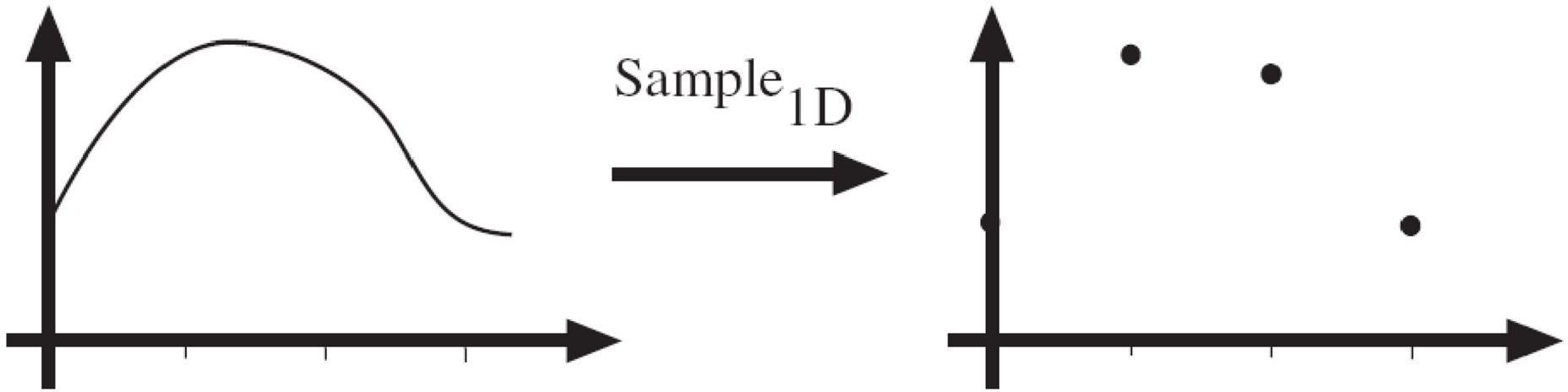
(b) Thermal Image



(d) fMRI

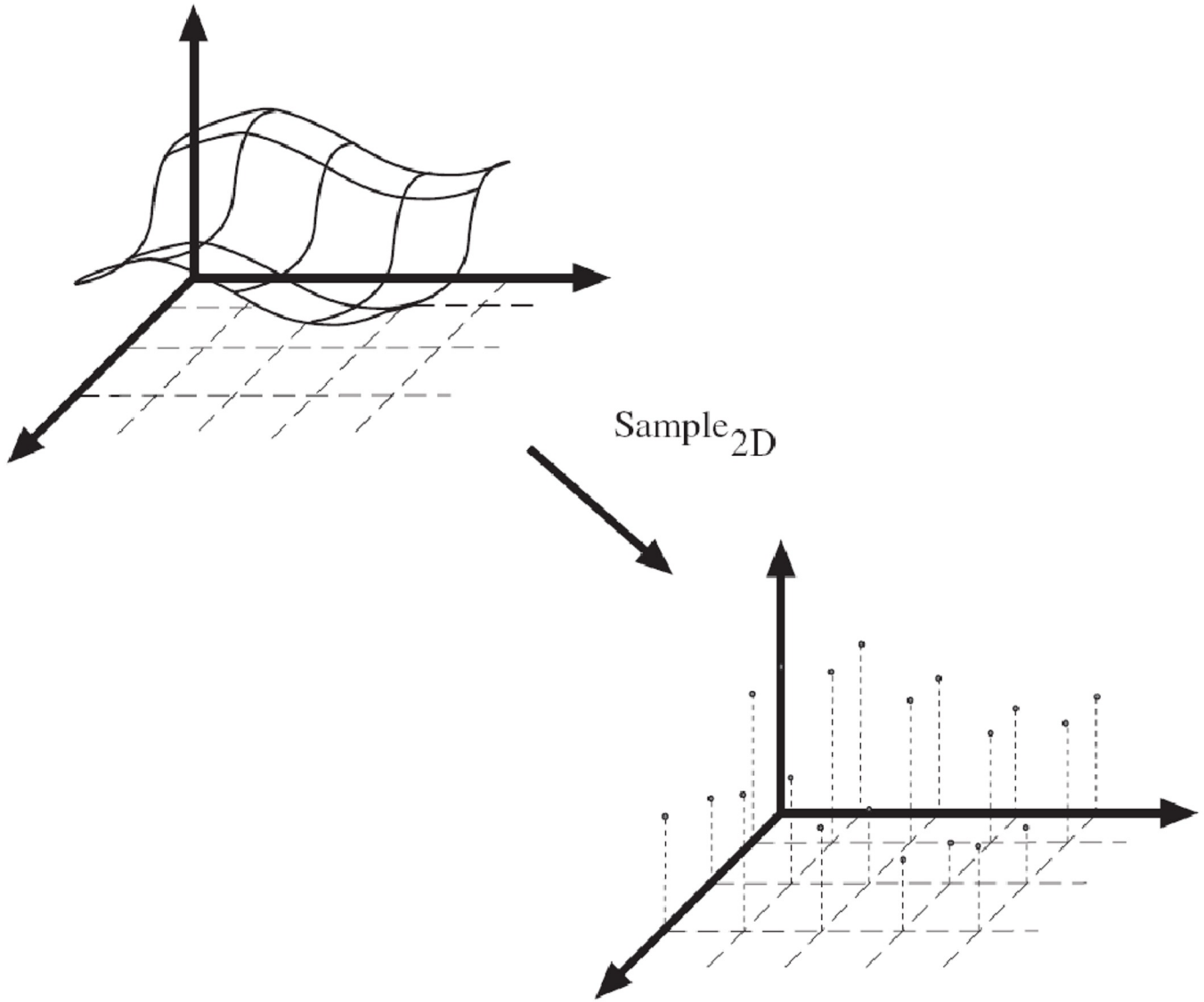
Sampling in 1D

- Sampling in 1D takes a function, and returns a vector whose elements are values of that function at the sample points.



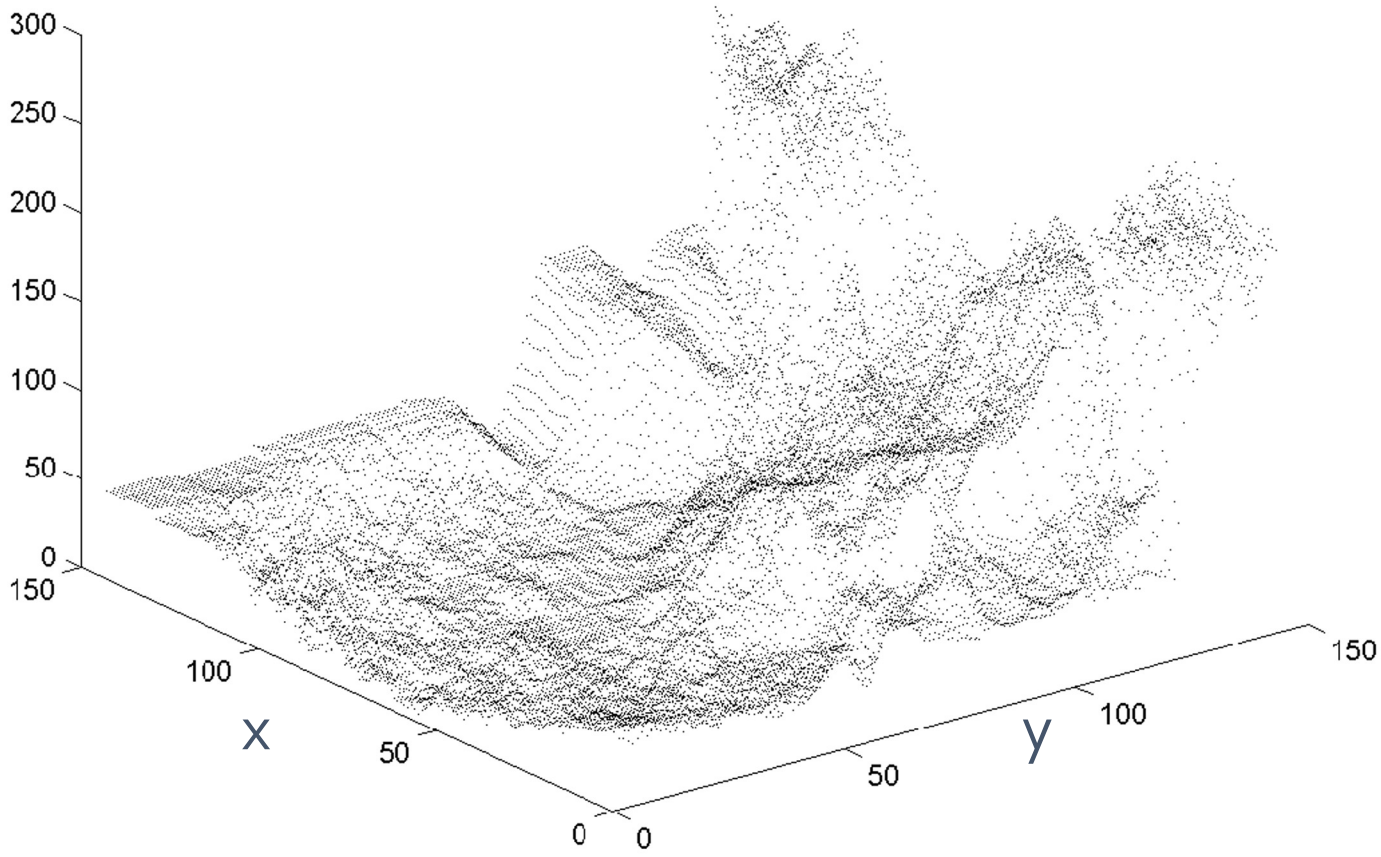
Sampling in 2D

- Sampling in 2D takes a function and returns a matrix.



Grayscale Digital In

Brightness
or intensity



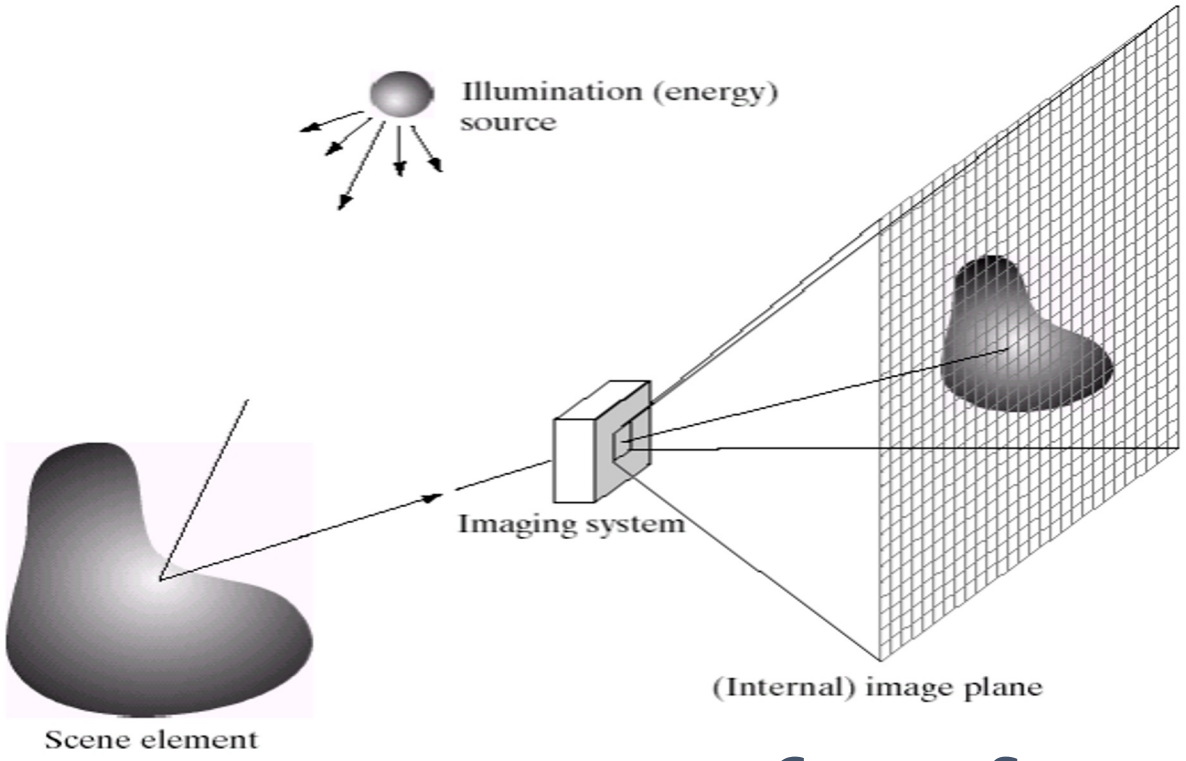
What is each part of a photograph?

Pixel ⟶ picture element

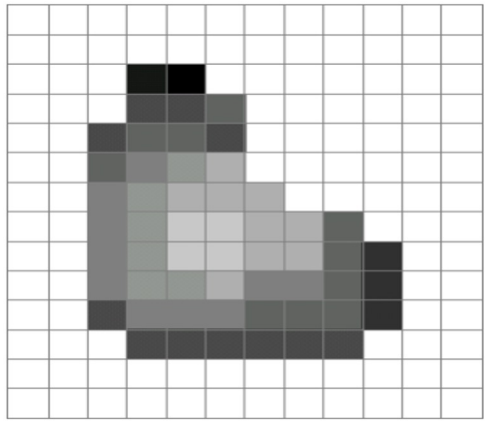
I(x,y)

‘127’

Integrating light over a range of angles.

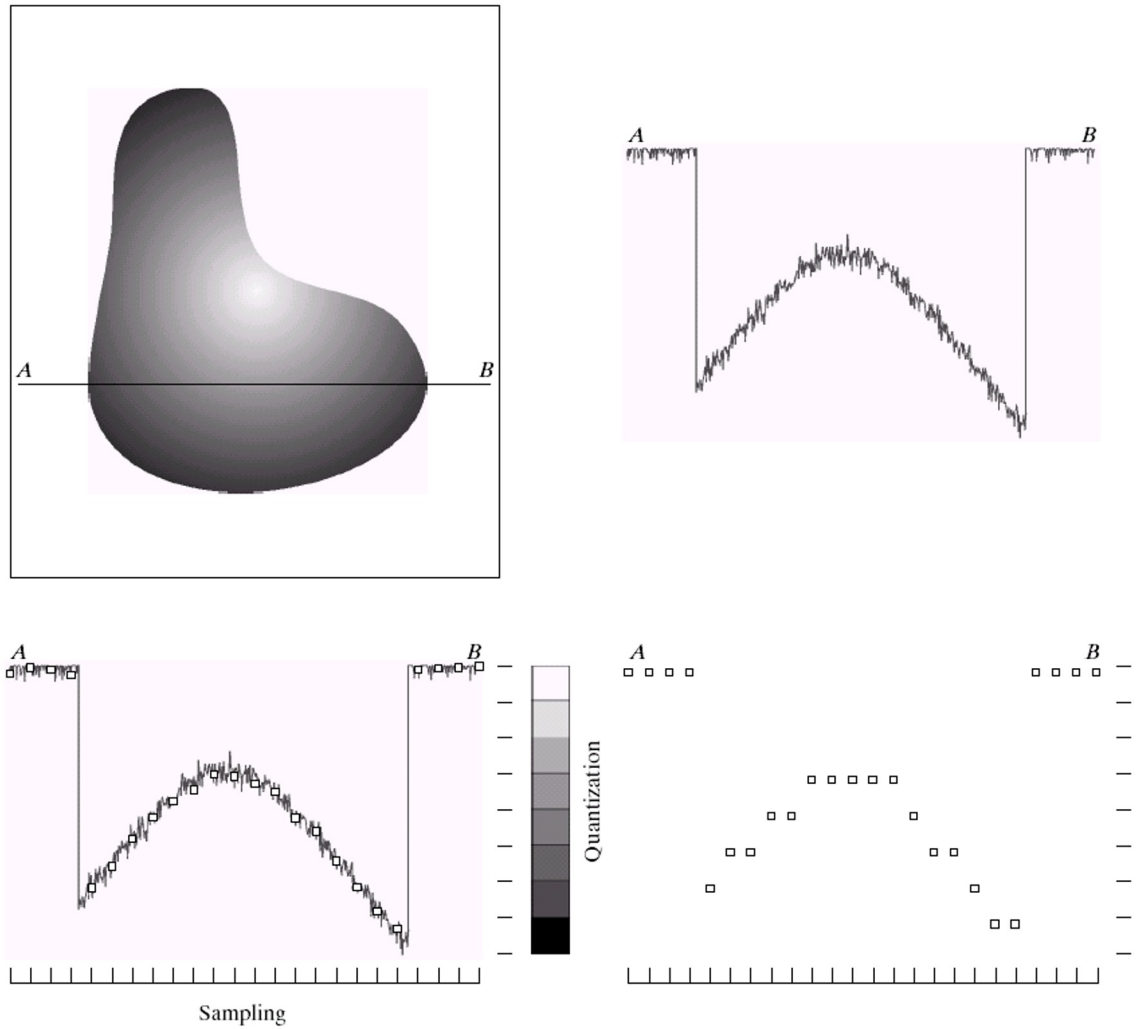


Camera Sensor



Output Image

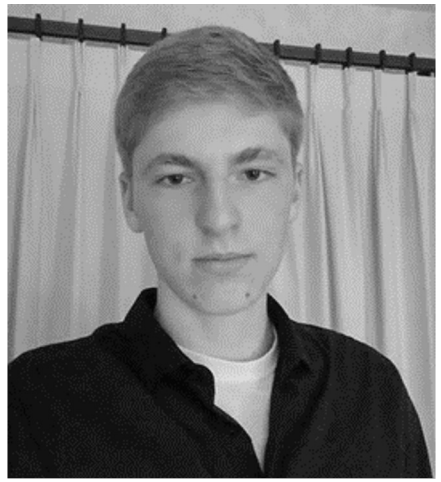
Quantization



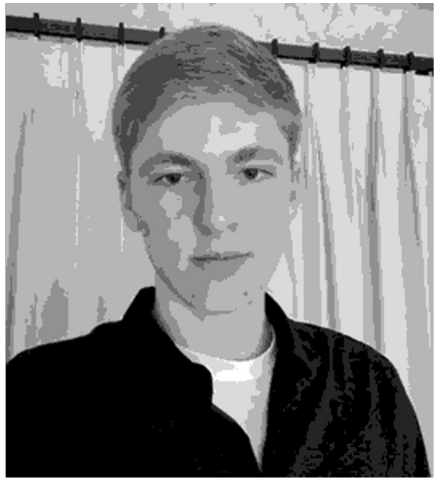
a b
c d

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.

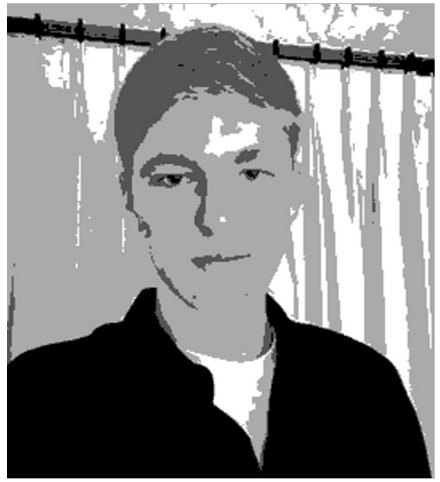
Quantization Effects – Radiometric Resolution



8 bit – 256 levels



4 bit – 16 levels



2 bit – 4 levels

1 bit – 2 levels

Resolution – Geometric vs. Spatial resolution

Both images are ~500x500 pixels: