绪论
Introduction

Contents

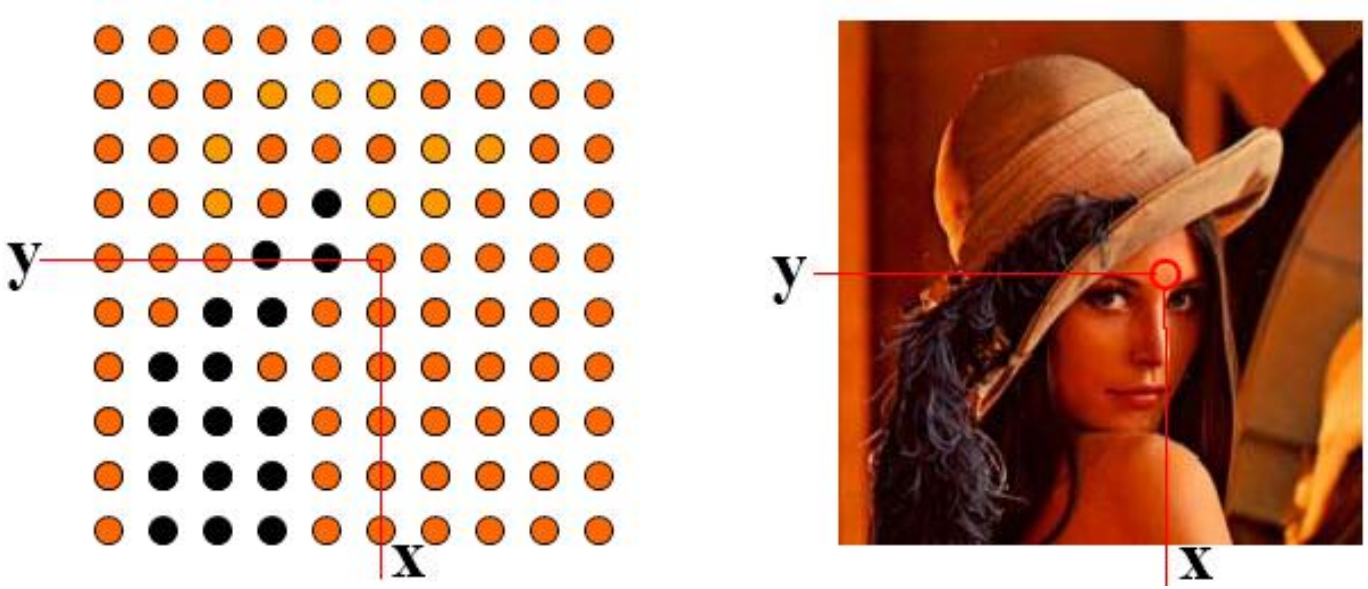
- What is digital image
- What is digital image processing
- The Origins of Digital Image Processing
- Application Fields
- Image Processing Systems

What is digital image

- **An image may be defined as a 2D function, $f(x,y)$,**
  - **where x and y are spatial coordinates, and amplitude of f is called *intensity* or *gray level* of image at that point**
  - ***Digital image*: when x, y and the amplitude values of f are all finite, discrete quantities**

What is digital image

- **Digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as *picture elements*, *image elements*, *pels*, and *pixels*.**

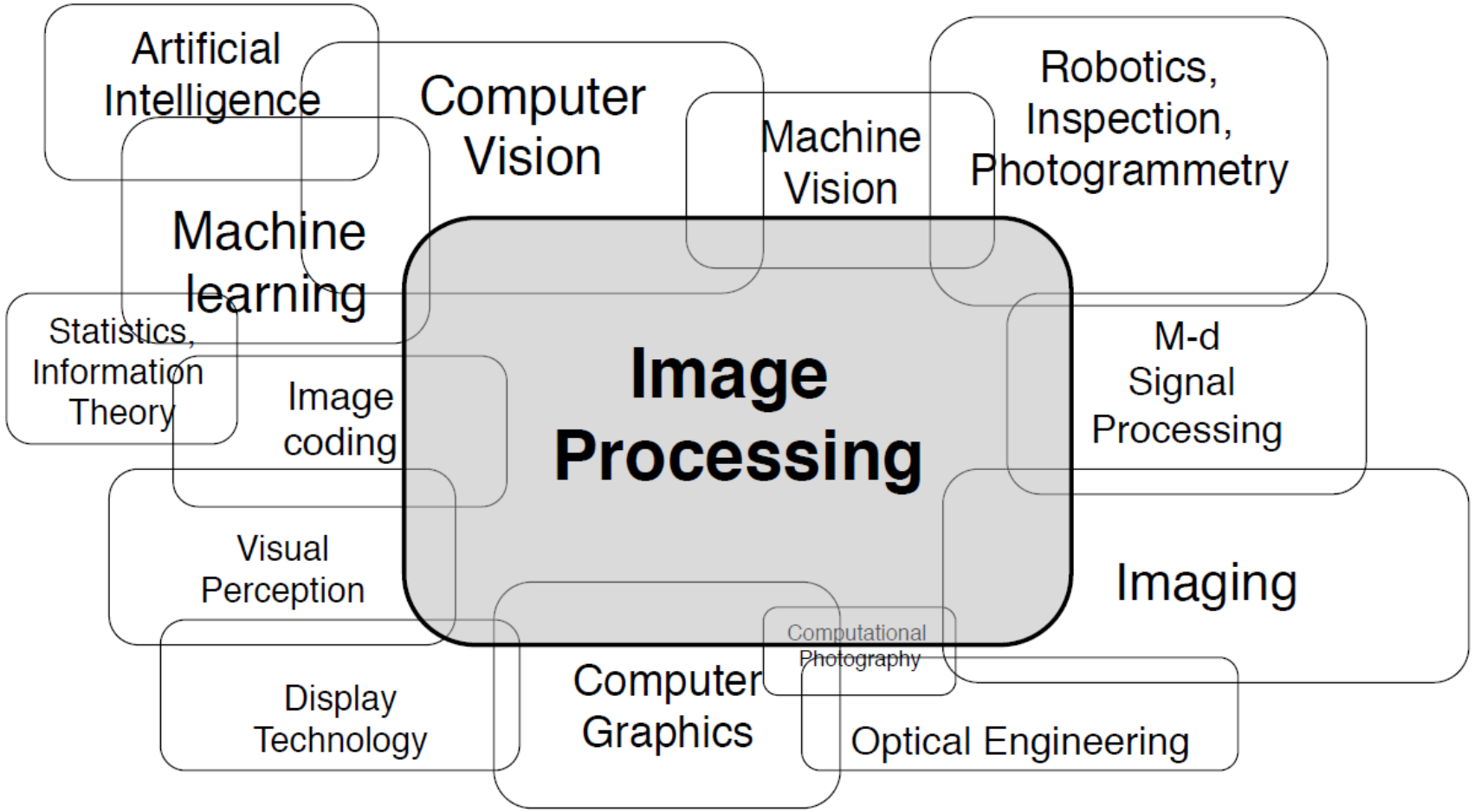


What is digital image processing

- **Digital image processing**
  - **Processing digital images by means of a digital computer**

- **Related fields**
  - **Image analysis (image understanding)**
  - **Computer vision**

Image Processing and Related Fields



Why do we process images?

- Acquire an image
  - *Correct aperture and color balance*
  - *Reconstruct image from projections*
- Prepare for display or printing
  - *Adjust image size*
  - *Color mapping, gamma-correction, halftoning*
- Facilitate picture storage and transmission
  - *Efficiently store an image in a digital camera*
  - *Send an image from space*
- Enhance and restore images
  - *Touch up personal photos*
  - *Color enhancement for security screening*
- Extract information from images
  - *Read 2-d bar codes*
  - *Character recognition*
- Many more ... image processing is ubiquitous








Source: Bernd Girod

The Origins of Digital Image Processing

- **One of the first applications of digital images was in the newspaper industry**
  - **Bartlane cable picture transmission system in the early 1920s reduced the time required to transport a picture across the Atlantic from more than a week to less than 3 hours**

FIGURE 1.1 A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces. (McFarlane.)

The Origins of Digital Image Processing

The improvements over Fig 1.1 are evident, both in tonal quality and resolution

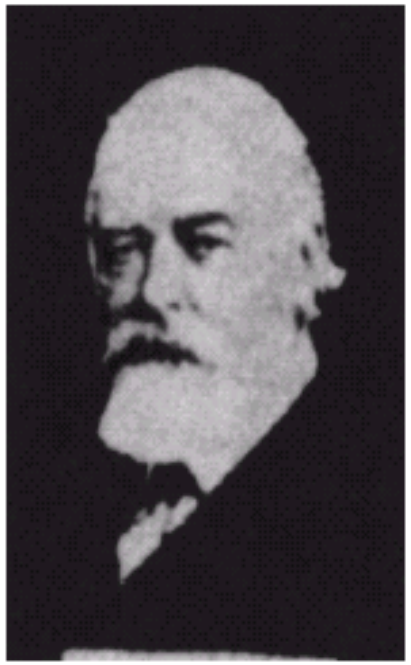


FIGURE 1.2 A digital picture made in 1922 from a tape punched after the signals had crossed the Atlantic twice. Some errors are visible. (McFarlane.)

The Origins of Digital Image Processing

- **The early Bartlane systems were capable of coding images in 5 distinct levels of gray. This capability was increased to 15 levels in 1929**

FIGURE 1.3
Unretouched cable picture of Generals Pershing and Foch, transmitted in 1929 from London to New York by 15-tone equipment. (McFarlane.)

The Origins of Digital Image Processing

- **The first computers powerful enough to carry out meaningful image processing tasks appeared in the early 1960s**
  - **Jet Propulsion Laboratory (JPL): pictures of the moon transmitted by Range 7 were processed by a computer to correct image distortion inherent in the on-board television camera**

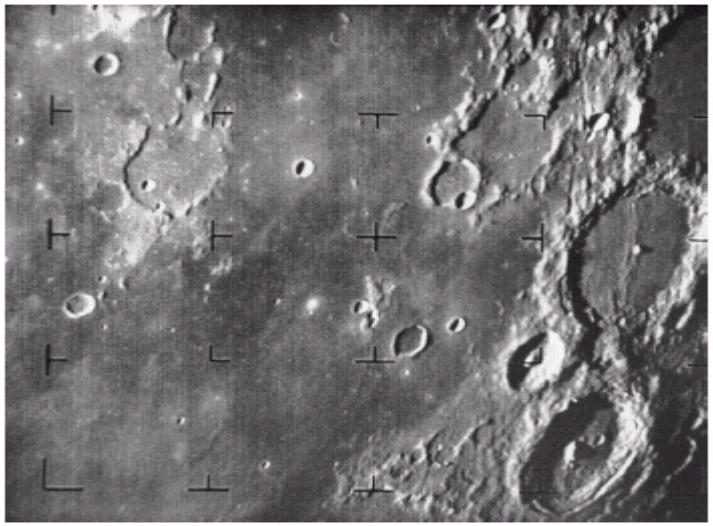


FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9:09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

The Origins of Digital Image Processing

- **In parallel with space applications, digital image processing techniques began in the late 1960s and early 1970s to be used in**
  - **Medical imaging**
    - **early 1970s，the invention of computerized tomography (CT)**
    - **G. N. Hounsfield and A. M. Cormack shared the 1979 Nobel Prize in Medicine for their invention**
  - **Remote Earth resources observations**
  - **Astronomy**

The Origins of Digital Image Processing

- From the 1960s until the present, the field of image processing has grown vigorously
- In addition to applications in medicine and the space program, digital image processing techniques now are used in a broad range of applications
- Two major application areas
  - Human interpretation
  - Machine perception

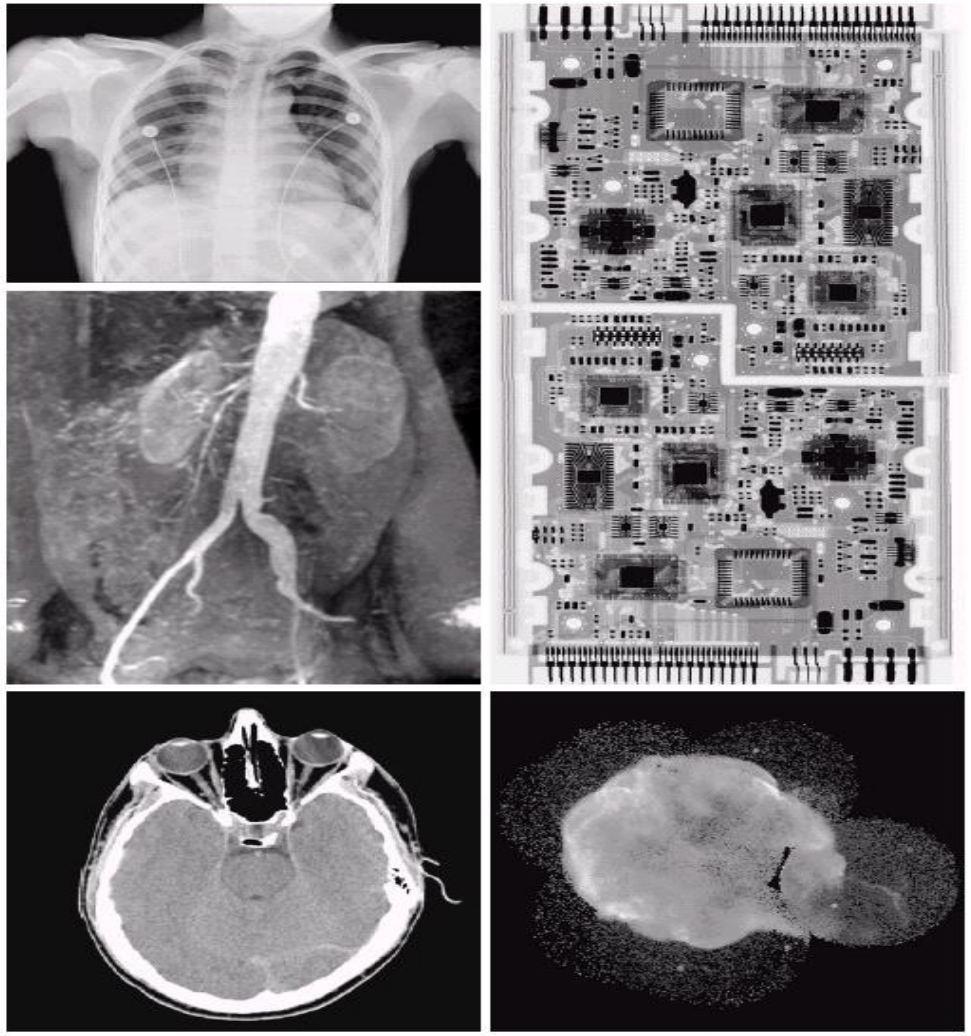
Examples of Application Fields

- **Human interpretation**
  - **X-rays image enhancement (industry, medicine)**
  - **Study pollution patterns from aerial and satellite imagery**
  - **Image enhancement and restoration procedures used to process degraded images**

Examples of Application Fields

- **Machine perception**
  - **Optical Character Recognition (OCR)**
  - **Biometrics (face, fingerprint, iris …)**
  - **Automatic object recognition (military)**
  - **Industrial machine vision for product assembly and inspection**

Examples of Application Fields



Examples of Application Fields

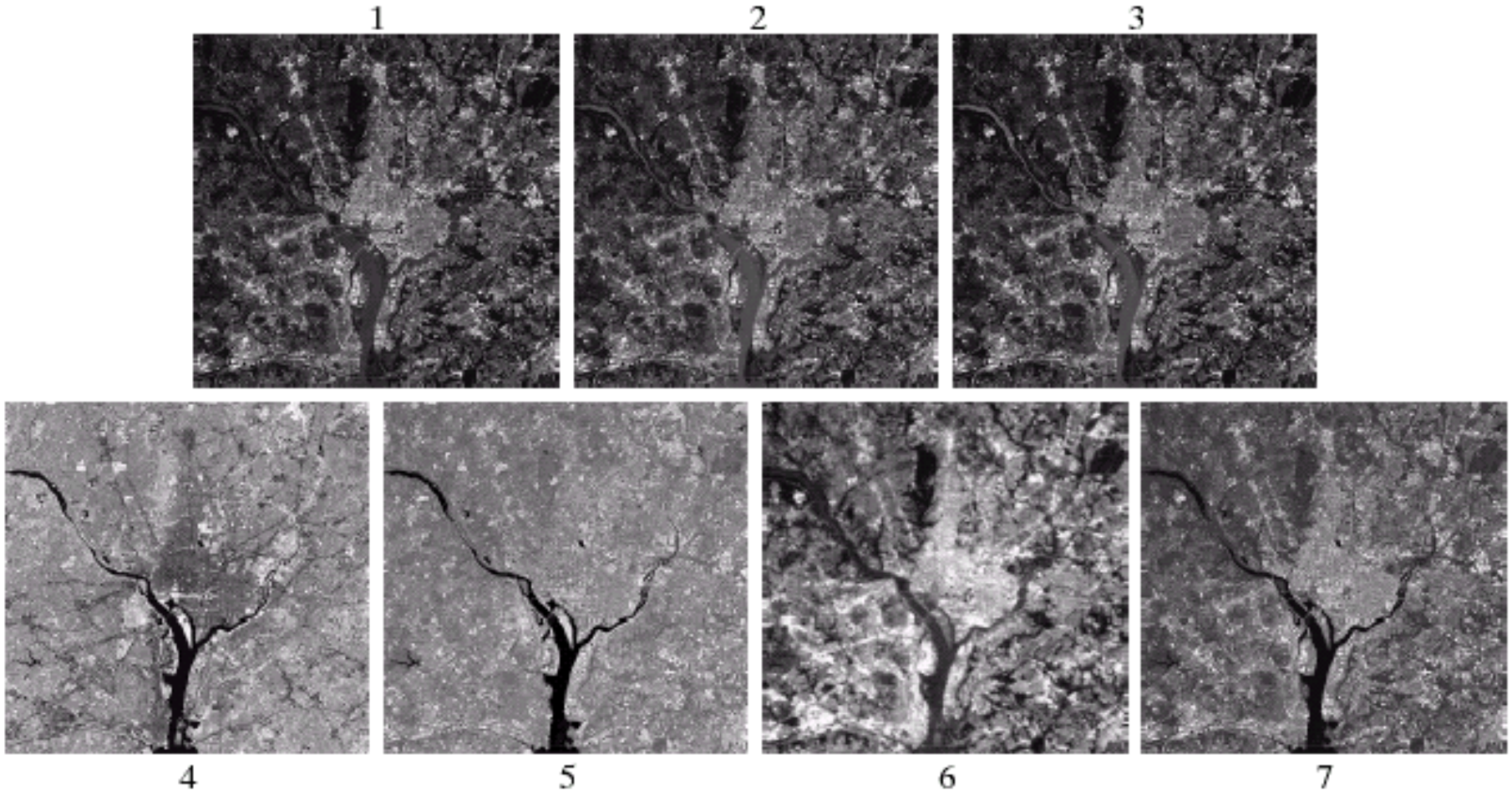
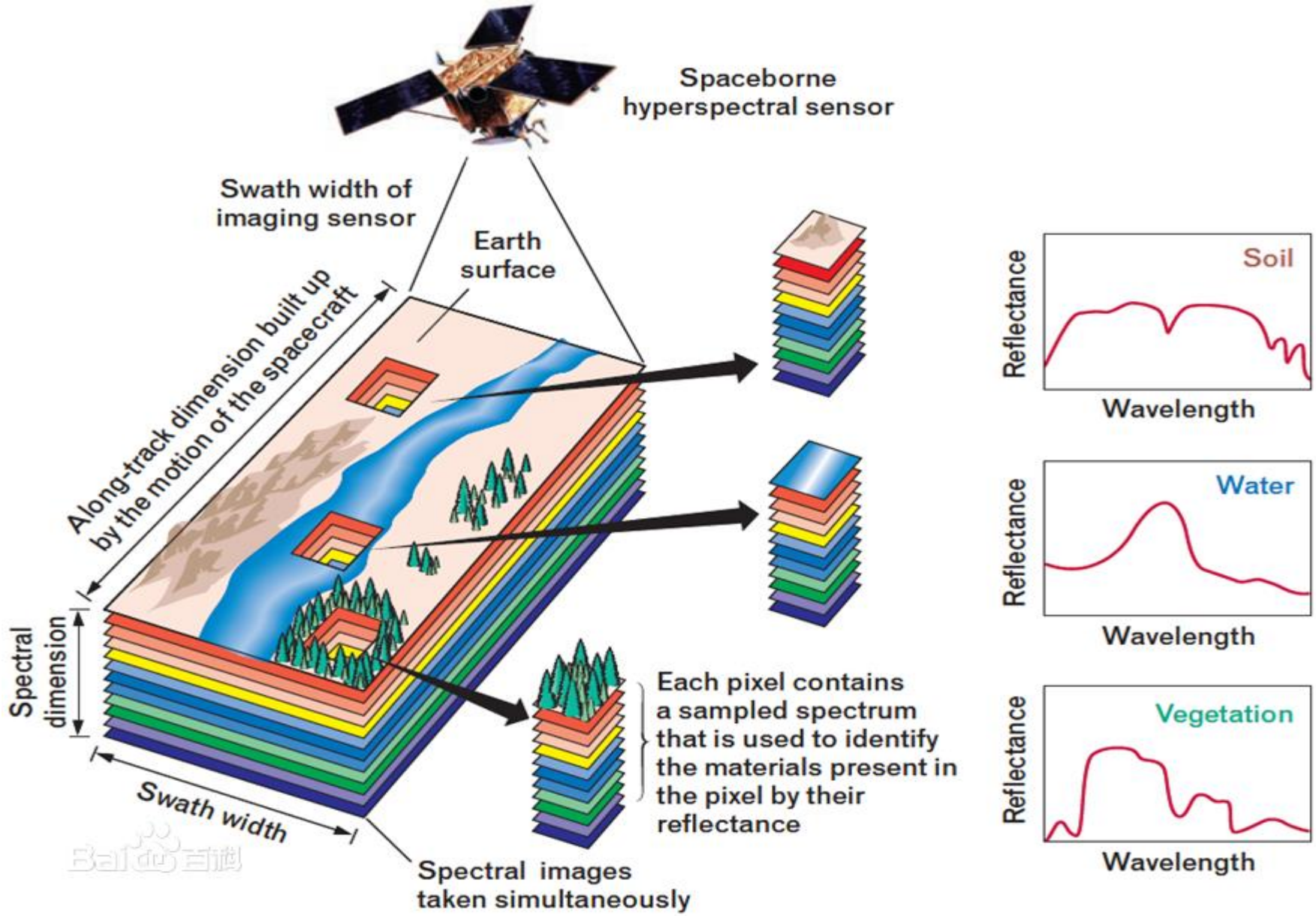
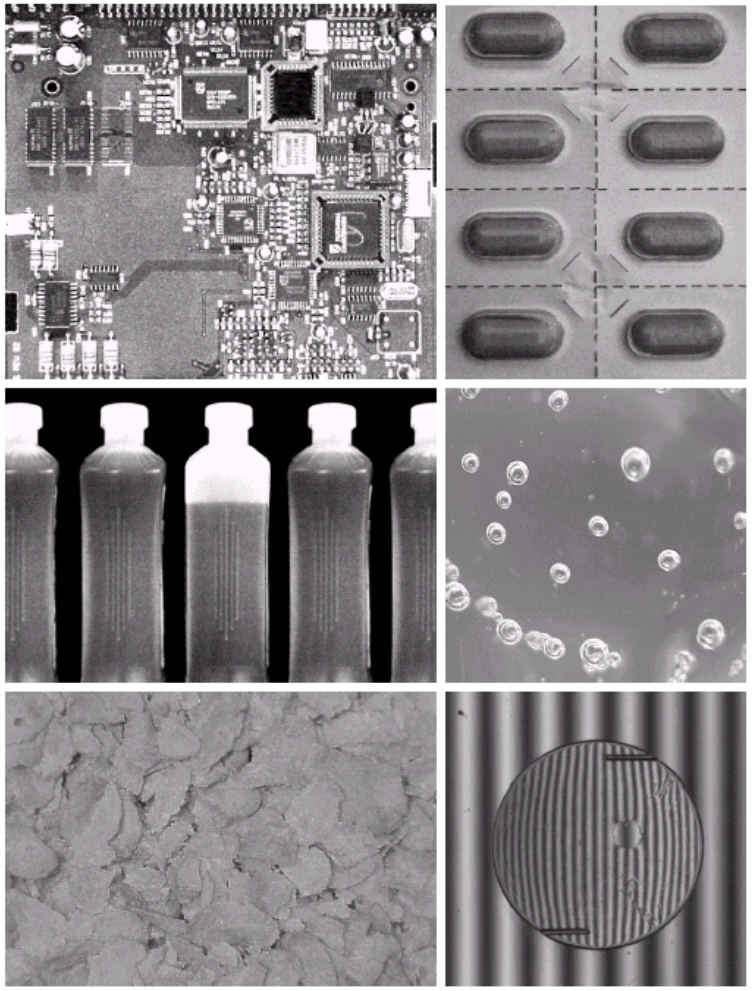


FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)


Spaceborne
hyperspectral sensor
Swath width of
imaging sensor
Earth
surface
Along-track dimension built up
by the motion of the spacecraft
Spectral
dimension
Swath width
Each pixel contains
a sampled spectrum
that is used to identify
the materials present in
the pixel by their
reflectance
Spectral images
taken simultaneously
Reflectance
Soil
Wavelength
Reflectance
Water
Wavelength
Reflectance
Vegetation
Wavelength

Examples of Application Fields



Examples of Application Fields

De-noising

Salt and pepper noise

Super-resolution

In-painting

Bertamio et al

Examples of Application Fields

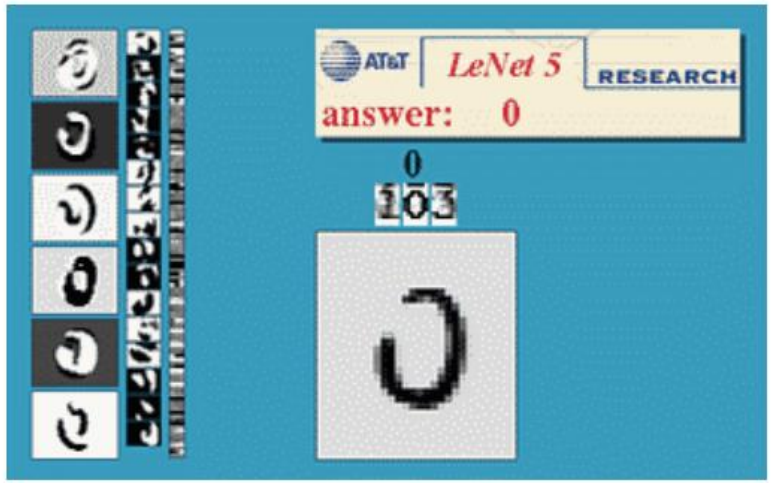
Examples of Application Fields

Biometrics: Iris recognition

Examples of Application Fields

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software



Digit recognition, AT&T labs

License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

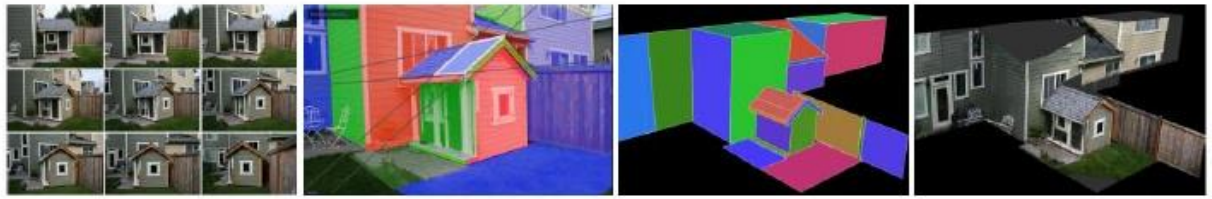
Source: S. Seitz

Examples of Application Fields

(a)

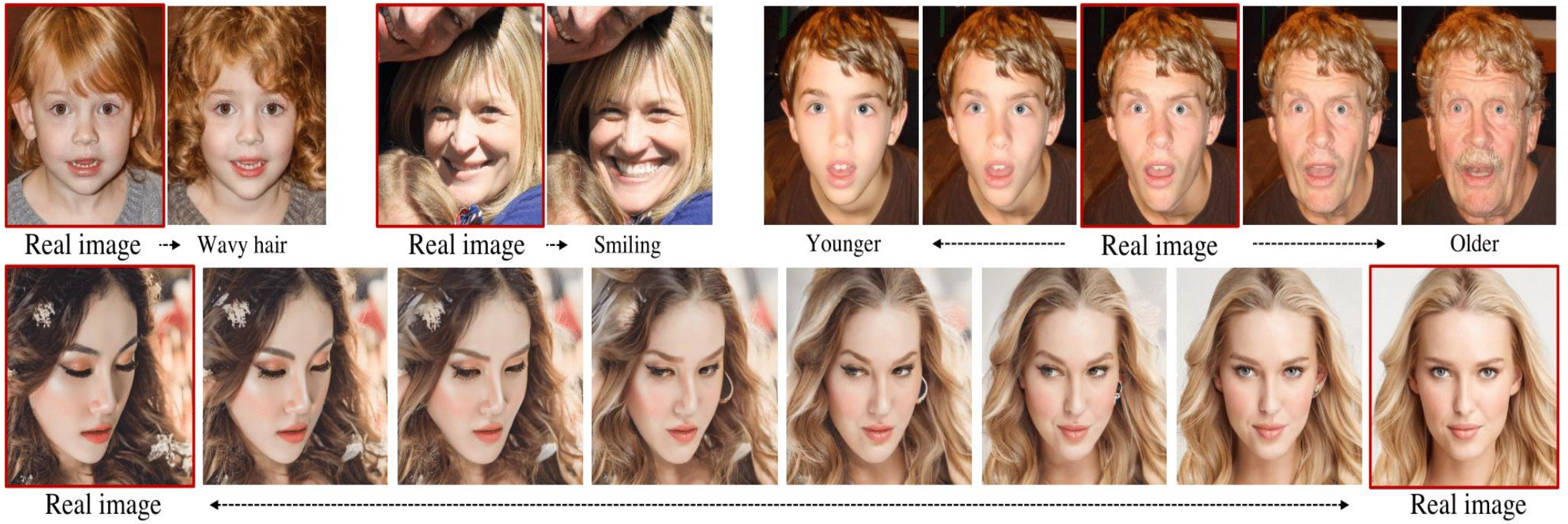
(b)

(c)



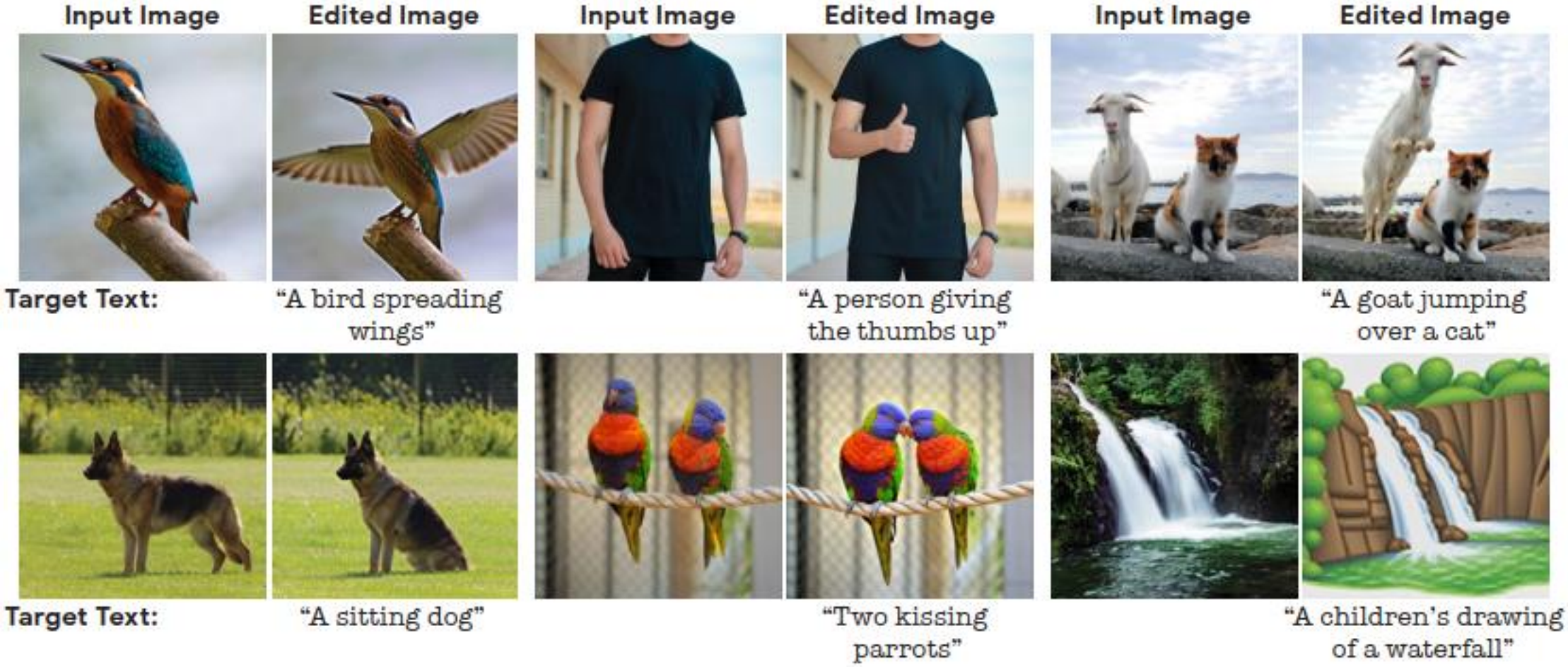
Input Photographs | 2D Sketching Interface | Geometric Model | Texture-mapped model

Examples of Application Fields



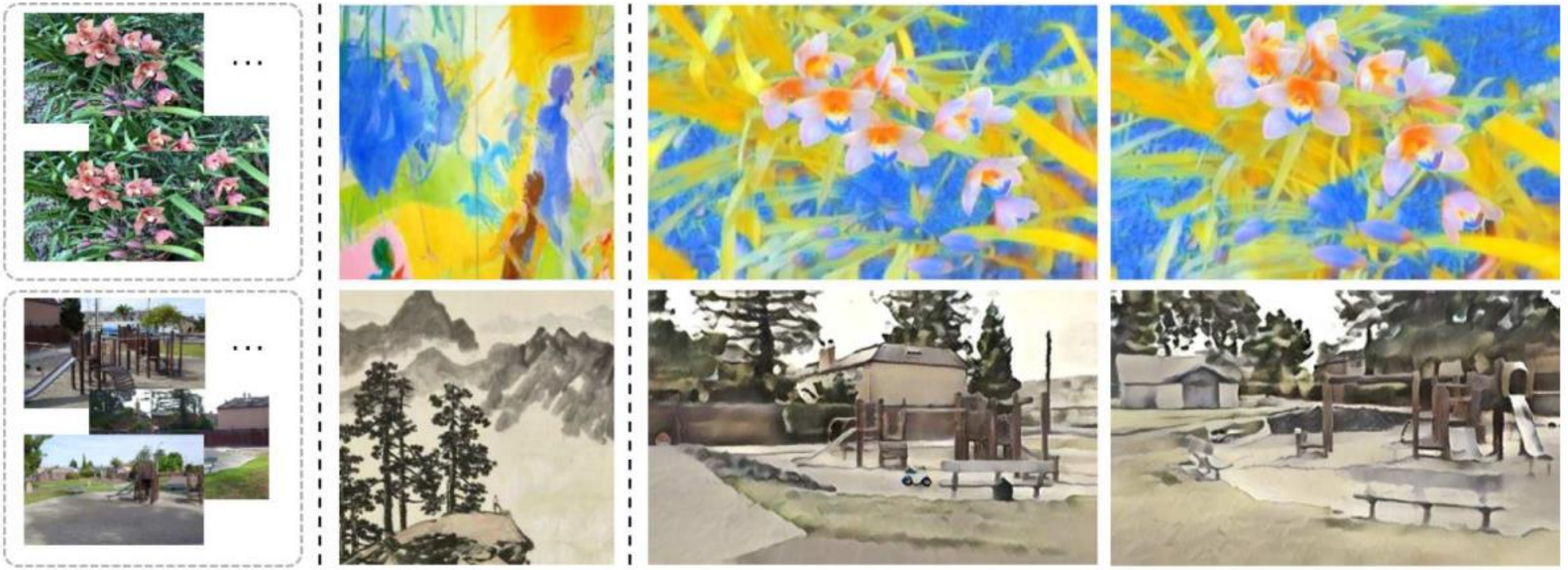
Diffusion Autoencoders: Toward a Meaningful and Decodable Representation (diff-ae.github.io)

Examples of Application Fields



Imagic: Text-Based Real Image Editing with Diffusion Models (imagic-editing.github.io)

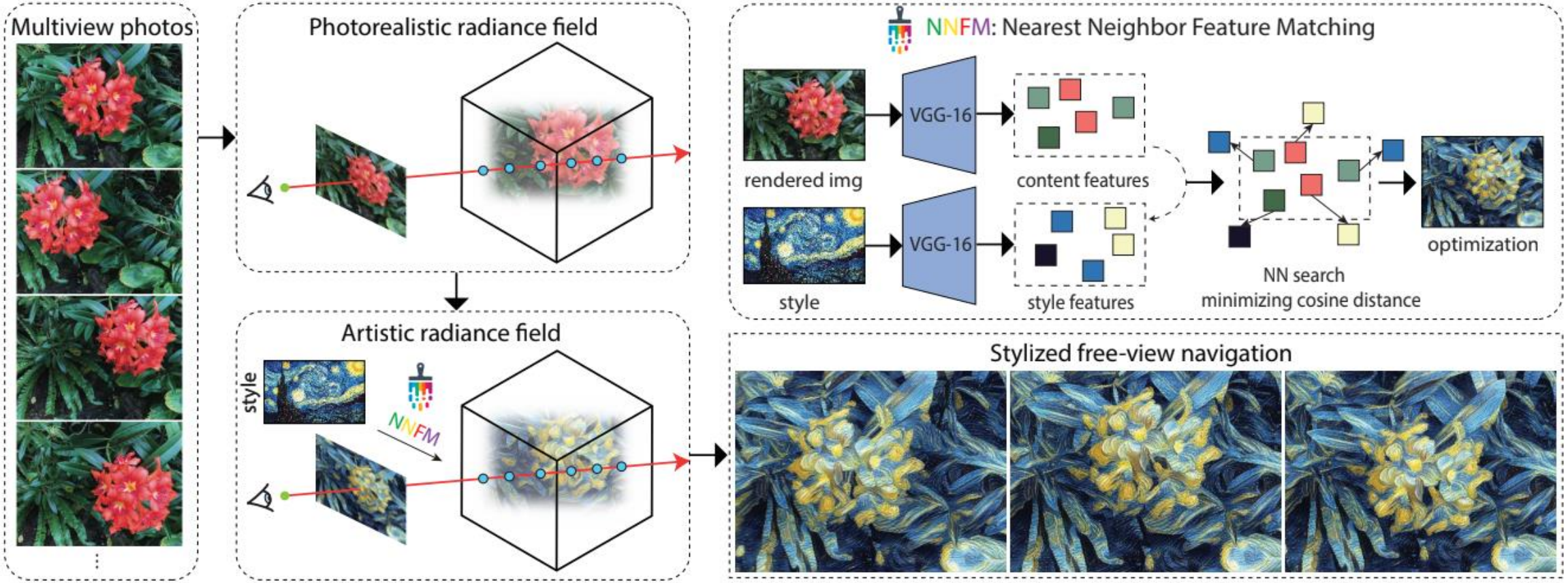
Examples of Application Fields



(a) Input views (b) Style image (c) Stylized novel views

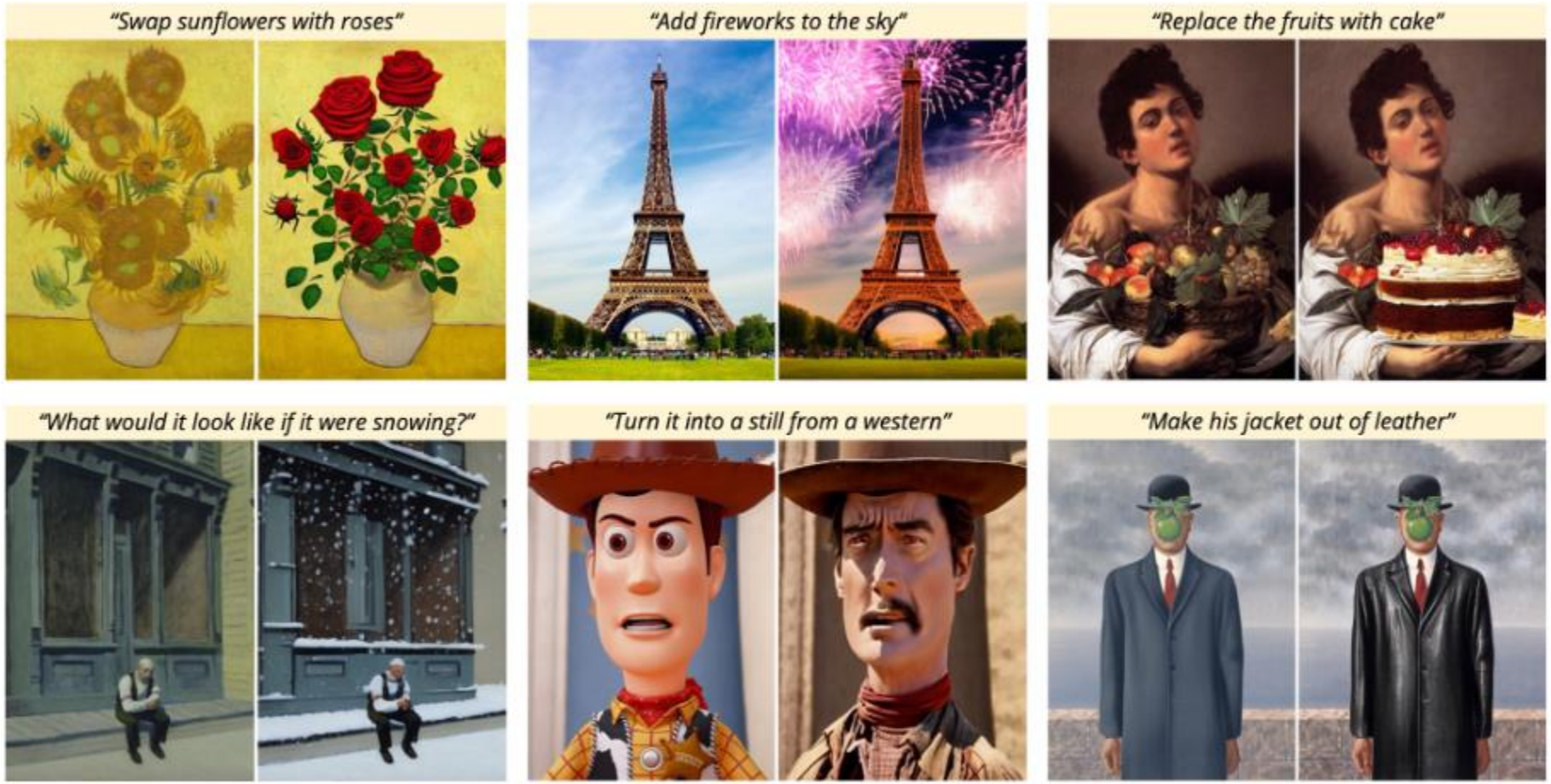
StylizedNeRF (geometrylearning.com)

Examples of Application Fields



ARF: Artistic Radiance Fields (cornell.edu)

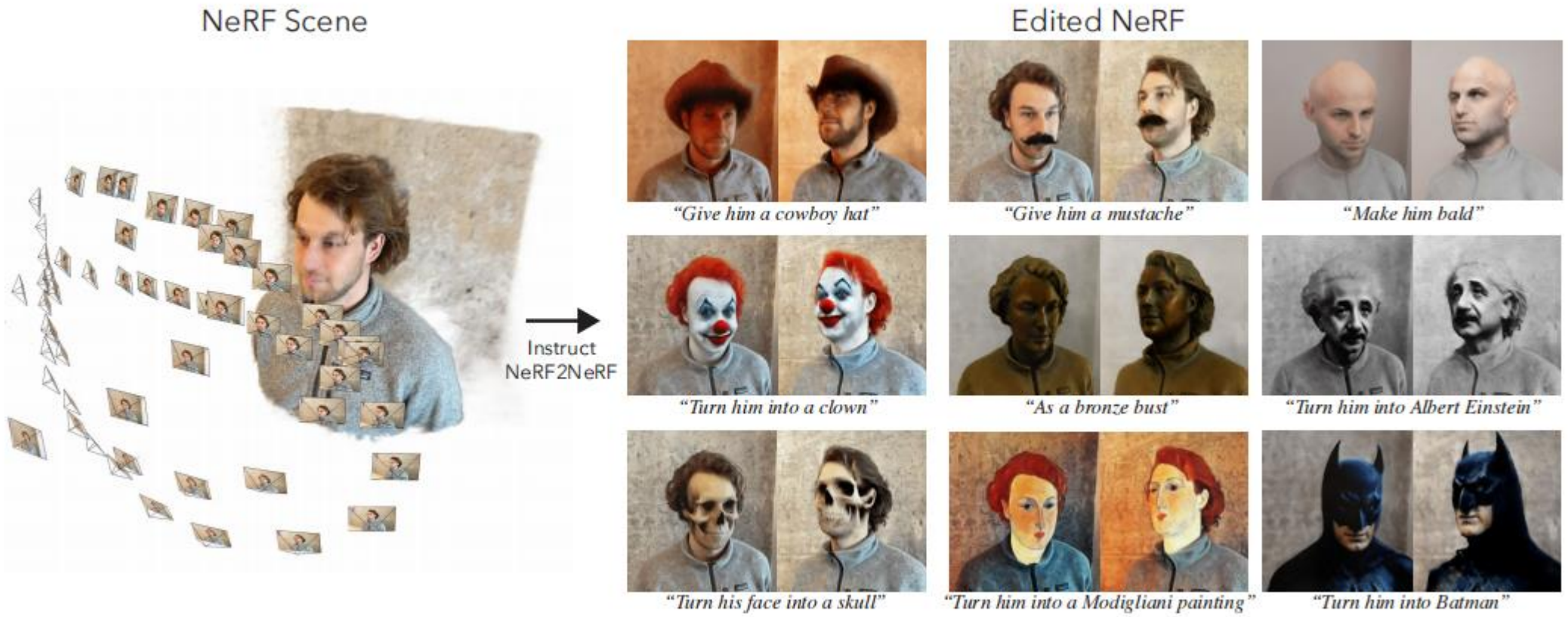
Examples of Application Fields



Given an image and a written instruction, our method follows the instruction to edit the image.

InstructPix2Pix (timothybrooks.com)

Examples of Application Fields

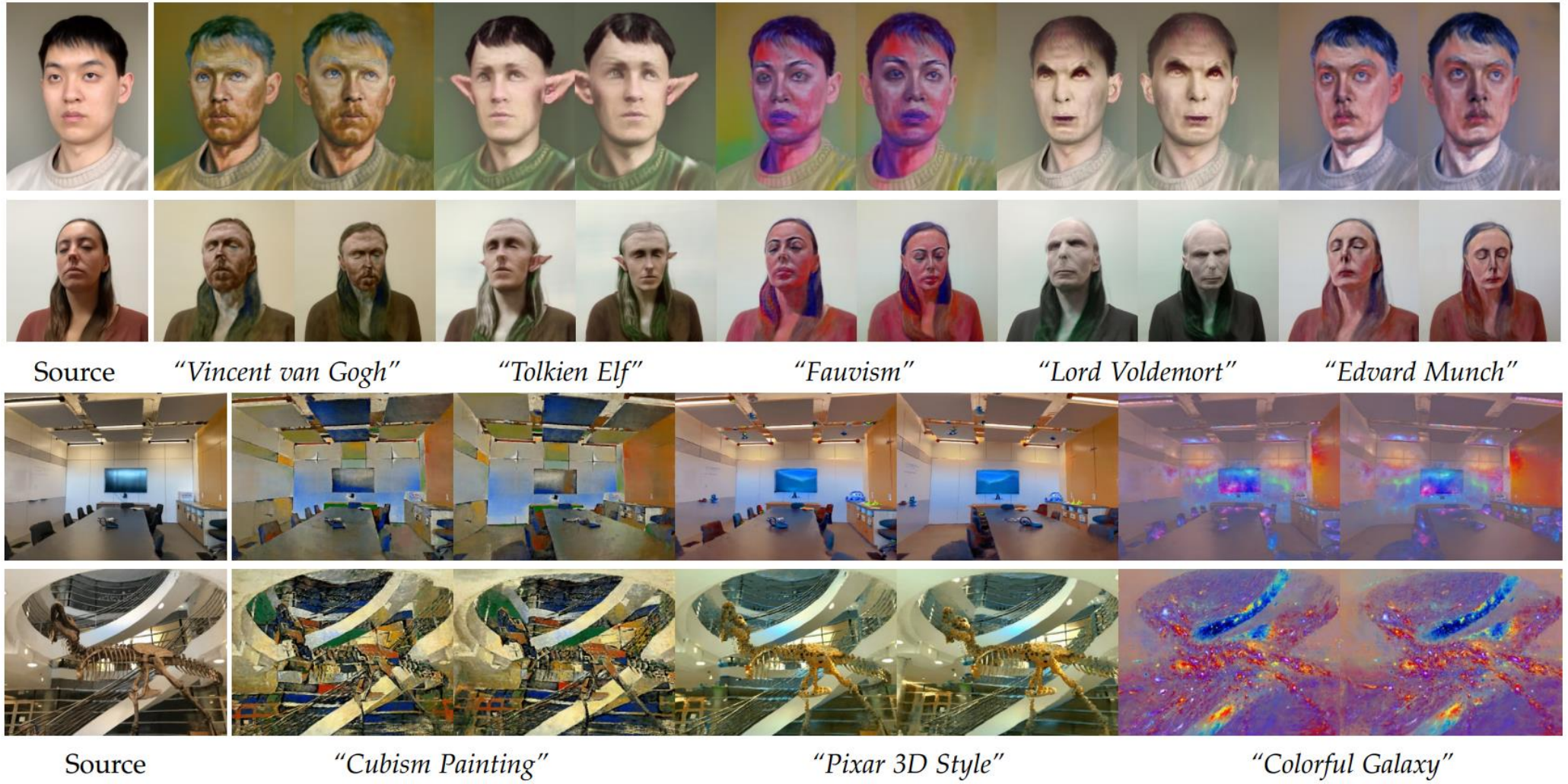


Instruct-NeRF2NeRF: Editing 3D Scenes with Instructions

Examples of Application Fields

Instruct-NeRF2NeRF: Editing 3D Scenes with Instructions

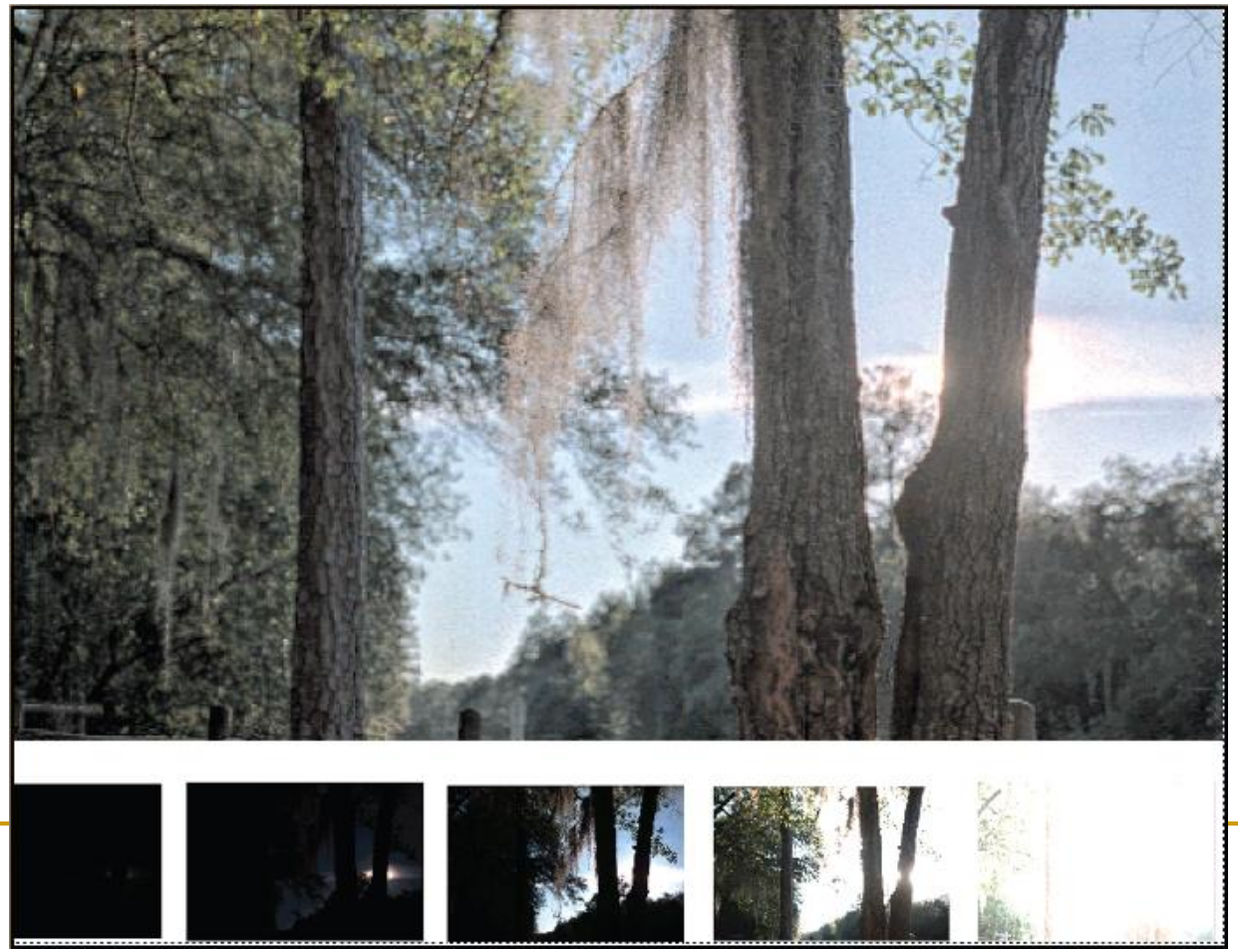
Examples of Application Fields



NeRF-Art: Text-Driven Neural Radiance Fields Stylization (cassiepython.github.io)

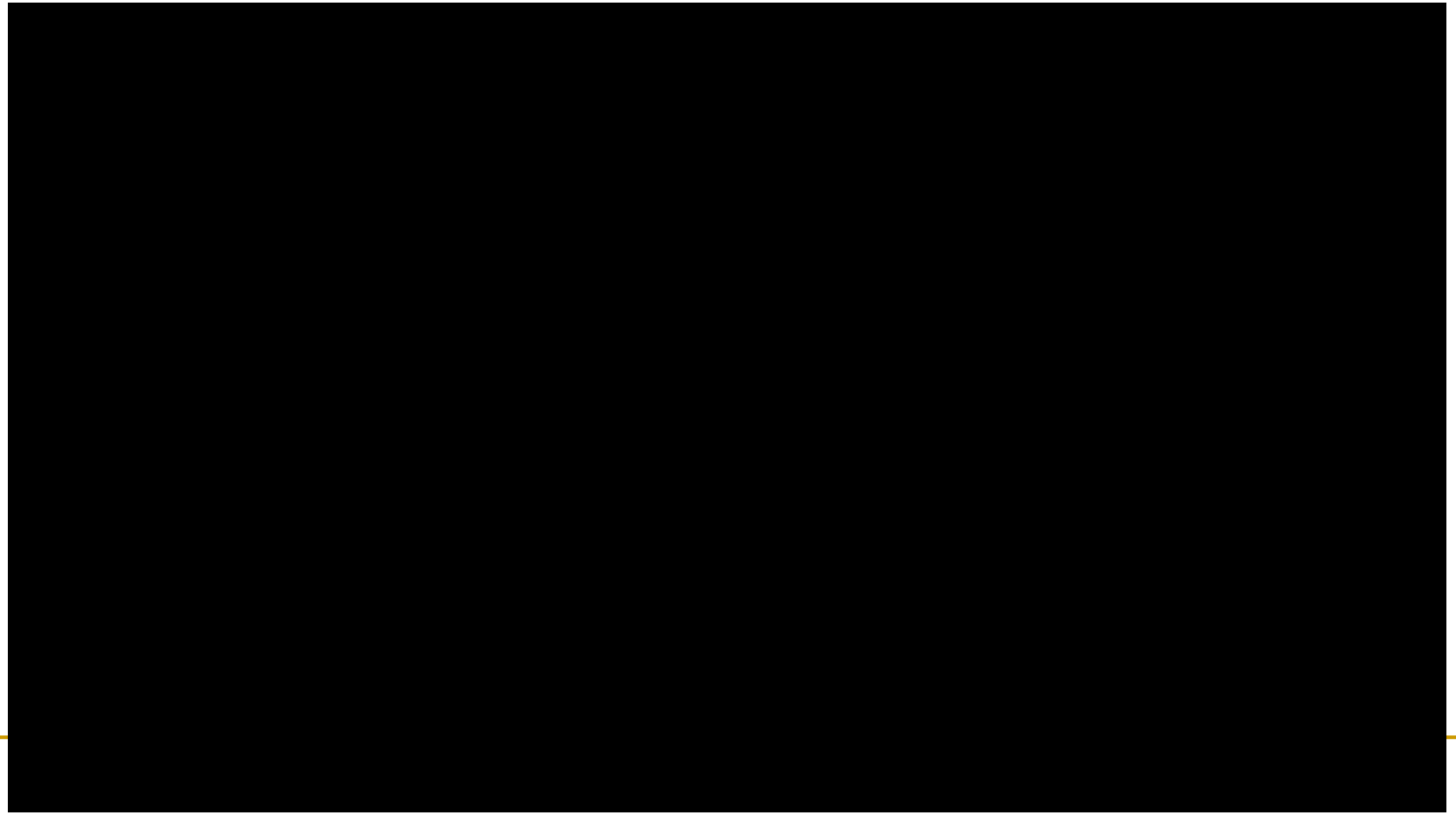
Examples of Application Fields

- **High Dynamic Range Images**



Examples of Application Fields

- **High Dynamic Range Images**



Examples of Application Fields

- **High Dynamic Range Images**

2022年中国前五大智能手机厂商——出货量、市场份额、同比增幅（单位：百万台）			
厂商	2022年全年市场份额	2021年全年市场份额	同比增幅
1. vivo	18.6%	21.5%	-25.1%
2. Honor	18.1%	11.7%	34.4%
3. OPPO*	16.8%	20.4%	-28.2%
3. Apple*	16.8%	15.3%	-4.4%
5. Xiaomi	13.7%	15.5%	-23.7%
其他	16.0%	15.6%	-11.2%
合计	100.0%	100.0%	-13.2%
来源：IDC中国季度手机市场跟踪报告，2022年第四季度			

Fundamental Steps in Image Processing

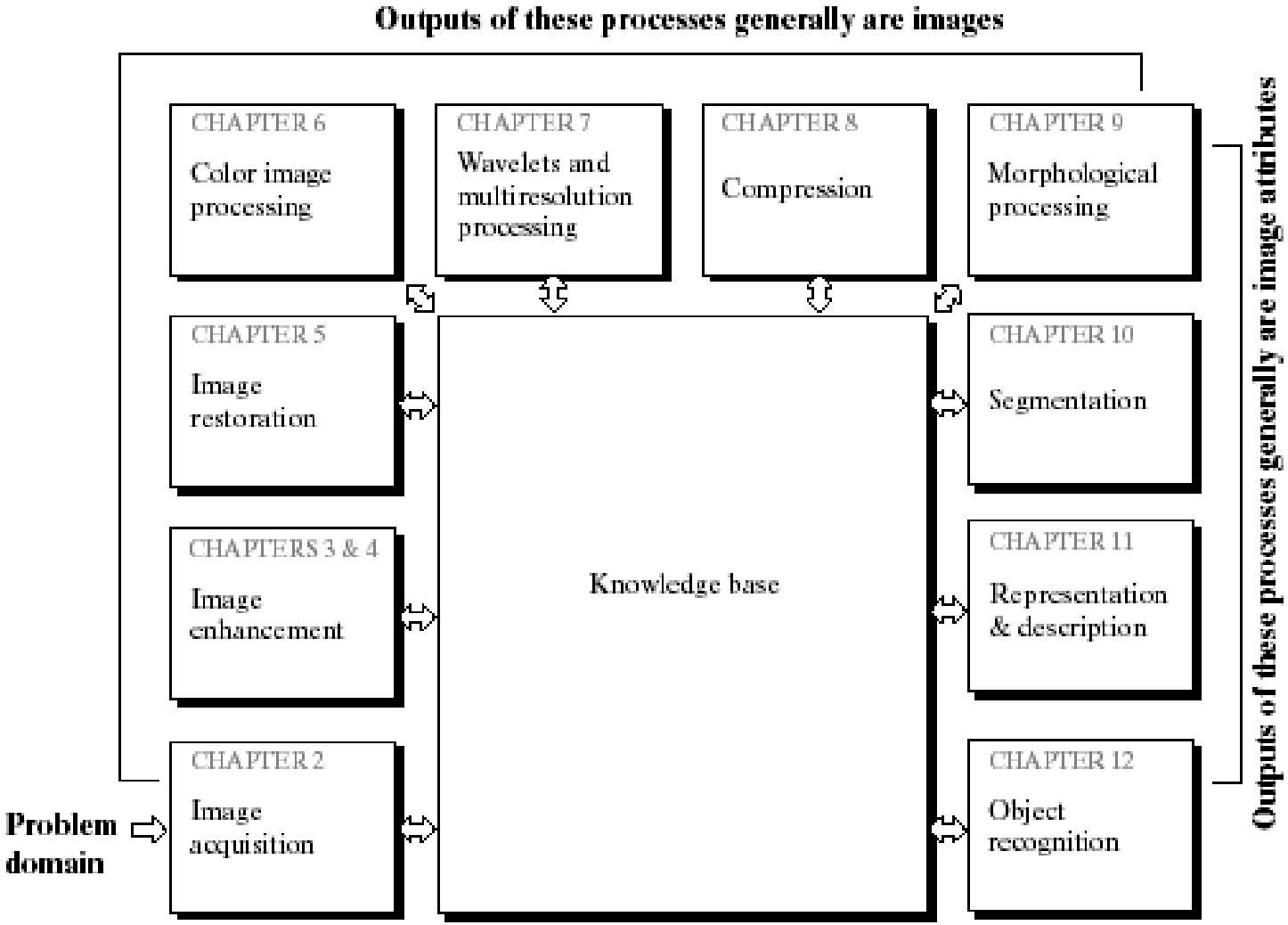


Image Processing Systems

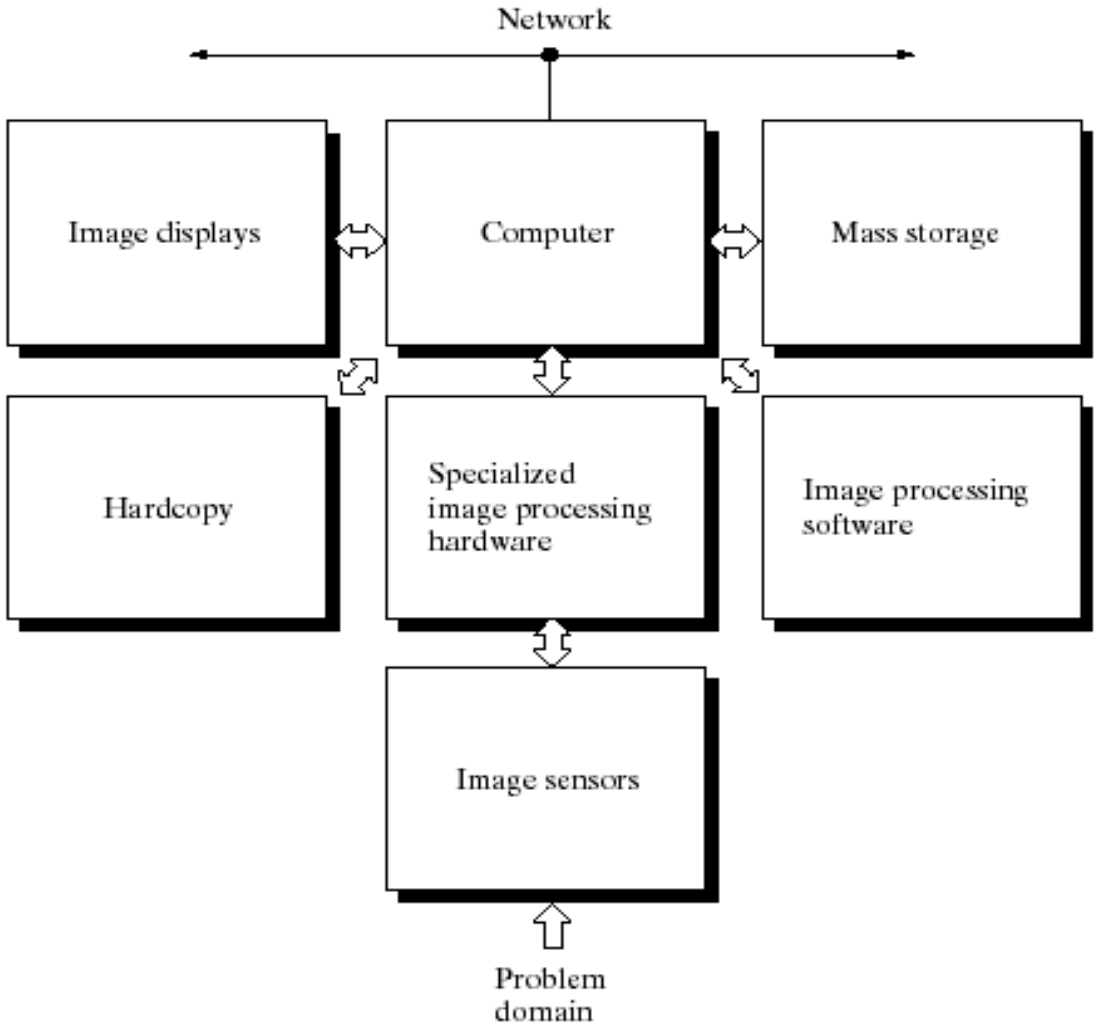


FIGURE 1.24
Components of a general-purpose image processing system.

Image Processing Systems

- **With reference to *sensing*, two elements are required to acquire digital images**
  - **The first is a physical device that is sensitive to the energy radiated by the object we wish to image**
  - **The second, called a 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**

Image Processing Systems

- ***Specialized image processing hardware***
  - **usually consists of the digitizer just mentioned, plus hardware that performs other primitive operations, such as arithmetic logic unit (ALU), which performs arithmetic and logical operations in parallel on entire images**
  - **One example of how an ALU is used is in averaging images as quickly as they are digitized, for purpose of noise reduction**

Image Processing Systems

- **The *computer* in an image processing system is a general-purpose computer and can range from a PC to a supercomputer**

- ***Software* for image processing consists of specialized modules that perform specific tasks**
  - **Software packages**

Image Processing Systems

- ***Mass storage*** **capability is a must in image processing applications. Digital storage for image processing applications fall into three principal categories**
  - **(1) short-term storage for use during processing**
    - **Computer memory, frame buffers**
  - **(2) on-line storage for relatively fast recall**
    - **Magnetic disks or optical-media storage**
  - **(3) archival storage, characterized by infrequent access**
    - **Magnetic tapes and optical disks housed in “jukeboxes” are the usual media**

Image Processing Systems

- ***Image displays***
  - **Color TV monitors, CRT, LCD, …**
- ***Hardcopy***
  - **Laser printers, film cameras, heat-sensitive devices, inkjet units, …**
- ***Networking*** **is almost a default function in any computer system in use today**
  - **The key consideration in image transmission is bandwidth**

Summary

- What is digital image
- What is digital image processing
- The Origins of Digital Image Processing
- Application Fields
- Image Processing Systems

谢谢大家！