Sukkur IBA University, KandhKot Campus
Computer Science Department

Digital Image Processing

Instructor: Muzamil Hussain

Special Thanks to Prof. Zhang Rui, SJTU

Lecture 1

Introduction

- **What is Digital Image Processing?**

The field of digital image processing refers to processing digital images by means of a digital computer.

To get some prospective effects or useful information.

Outline

-
- Course Syllabus
-
-

Outline

- Examples of Digital Image Processing
- Course Syllabus
- Image & Image Processing
- Components of an Image Processing System

- "Today, there is almost no area of technical endeavor that is not impacted in some way by digital image processing."
（Rafael C. Gonzalez）

- **Examples**

1. **Public security**
   - -Video surveillance system
   - -Human face recognition & tracking
   - -Fingerprint enhancement & recognition

2. **Traffic**
   - -Car license plate recognition
   - -Vehicle recognition
   - -Electronic police

3. Universe exploration
   - -Airship
   - -Moon exploration

4. Telemetry
   - -Weather forecast
   - -Mineral resources detection

5. National defence
   - -ALV
   - -Pilotless aircraft
   - -Cruise missile

6. Biomedicine
   - -CT
   - -MRI

7. Other
   - -Cell phone
   - -Digital camera
   - -Digital recorder
   - -VOD
   - -WeChat
   - - …

Outline

- Examples of Digital Image Processing
- **Course Syllabus**
- Image & Image Processing
- Components of an Image Processing System

Course Description

- Introduces fundamental principles and practical techniques of digital image processing
- 3 parts
  - fundamental principles, including the theories of 2-D signal processing and visual psychology, results of information theory and image transform algorithms
  - human visual system based practical techniques, including the principles and the methods of image enhancement, image restoration, image compression and image reconstruction
  - content recognition and understanding based practical techniques, introduces the techniques of image segmentation and image description
- Reflects the new progress of digital image processing

Course Pre-requisites

- Digital Signal Processing
- Random Procedure

Textboo
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Digital Image Processing (Third Edition),

Rafael C. Gonzalez, Richard E. Woods, 2011

Learning Objectives

- **Knowledge and Understanding Skills**
  - **Develop an overview of the field**
  - **Have a knowledge and understanding of the basic principles of different image processing techniques**
  - **Have a knowledge and understanding of image transformations, image enhancement, image restoration, image reconstruction, image compression, image segmentation and image description**

Learning Objectives

- **Practical and subject specific skills**
  - **Be able to use MATLAB to get experimental results**
  - **Perform different algorithms of image transformation, image enhancement, image restoration, image reconstruction, image compression, image segmentation and image description**
- **Cognitive skills (thinking and analysis)**
  - **Be able to choose proper algorithms to solve problems in real applications**

Learning Objectives

- **Creative skills**
  - Have the experience of designing new algorithms based on the fundamental techniques
- **Communicating skills**
  - Discuss with others and try to find the right way to solve a certain problem

Related Courses

- Pattern Recognition, Computer Vision, Artificial Intelligence
- Wavelet & Fractal, Neural Network, Digital Signal Processing, Information Theory
- Image/Video Communication
- Computer Graphics

Course Contents

- **8 chapters**

Fundamentals	1. Introduction 2. Digital Image Fundamentals 3. Image Transformations
Techniques related to HVS	4. Image Enhancement 5. Image Restoration & Reconstruction 6. Image Compression
Techniques related to recognition & comprehension	7. Image Segmentation 8. Image Description

Course Contents

PART One

1. Introduction
2. Digital Image Fundamentals
   - Sampling & Reconstruction
   - Quantization
   - Radiometry Fundamentals
   - Colorimetry Fundamentals
   - Human Visual System
   - Human Visual Models & Image Quality Assessment

3. Image Transformations

- Introduction
- 2D Discrete Fourier Transform
- 2D Discrete Cosine Transform
- Walsh-Hadamard Transform
- Karhunen-Loeve Transform
- Haar Transform
- Wavelet Transform

PART Two

1. Image Enhancement

- Gray Level Enhancement
- Image Filtering in Spatial Domain
- Image Filtering in Frequency Domain
- Median Filtering
- Other Methods of Image Enhancement

2. Image Restoration & Reconstruction

- Image Restoration
- Image Reconstruction

3. Image Compression

- Introduction of Image Compression
- Theoretical Fundamentals of Image Compression
- Entropy Coding
- Predictive Coding
- Transform Coding
- Wavelet Coding
- Image Compression Standards

PART Three

1. Image Segmentation

- Edge Detection
- Line Detecion
- Region-Based Segmentation
- Morphological Filering

2. Image Description

- Line Description
- Region Description

Evaluation Criteria

- Practice exercise10%
- Projects (demo + reports) 20%
- Mid exams 30%
- Final examination 40%

Assignments

- No cheating
- On time
- Late for class?

Evaluation Criteria for the Course

- Whether the students enjoy their time in class
- Whether the students can design their own methods for a certain problem
- The contents the students discuss with me

Contact Information

E-mail: muzamilhussain.kdk@iba-suk.edu.pk

Office Hour: Thursday 12:00-13:00

Students need to learn 4 things

- Learn to do
- Learn to be
- Learn to be with others
- Learn to how to learn

Assignment

Index of Learning Styles (ILS)

http://educationdesignsinc.com/index-of-learning-styles/

- Read “Learning Styles and Strategies”
- Complete “ILS questionnaire”, print the report
  - Name
  - Student No.
  - Interests

Outline

- Examples of Digital Image Processing
- Course Syllabus
- **Image & Image Processing**
- Components of an Image Processing System

Digital Image Processing

A B C

A. Image Acquisition

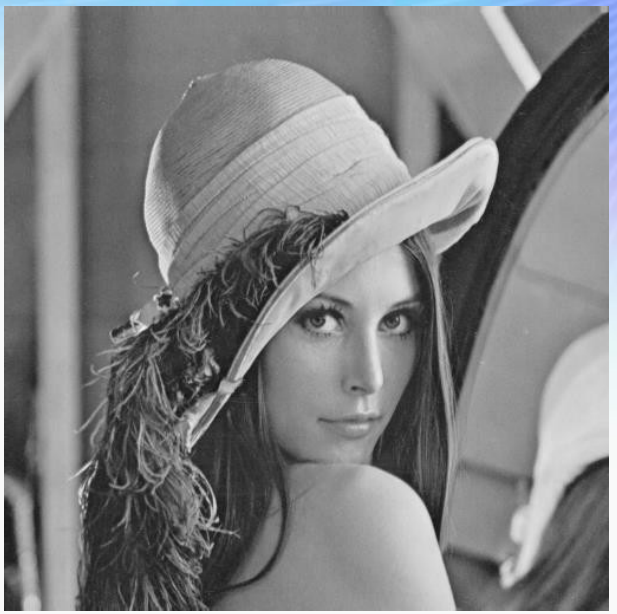
1. Image acquisition is the first step of digital image processing

- Analog image → Sampling, Quantization → Digital image
- Digital image processing vs. Analog image processing & Hybrid image processing

2. Different applications have different parameters with spatial resolution and quantization

- Spatial resolution : Digital movie, HDTV, SDTV, CIF, QCIF
- Quantization : 8bit/10bit/12bit

B. Digital image



1.Gray Scale Image

- I=f(x,y)
- I=f(m,n)（I: 0-255)
- Gray level
- Pixel/Pel

2.Binary Image

- f(m,n)∈{0,1}
- Printer/Newspaper
- Gray Level → 0/1

3.Color Image

- **Different wavelength results in different color**

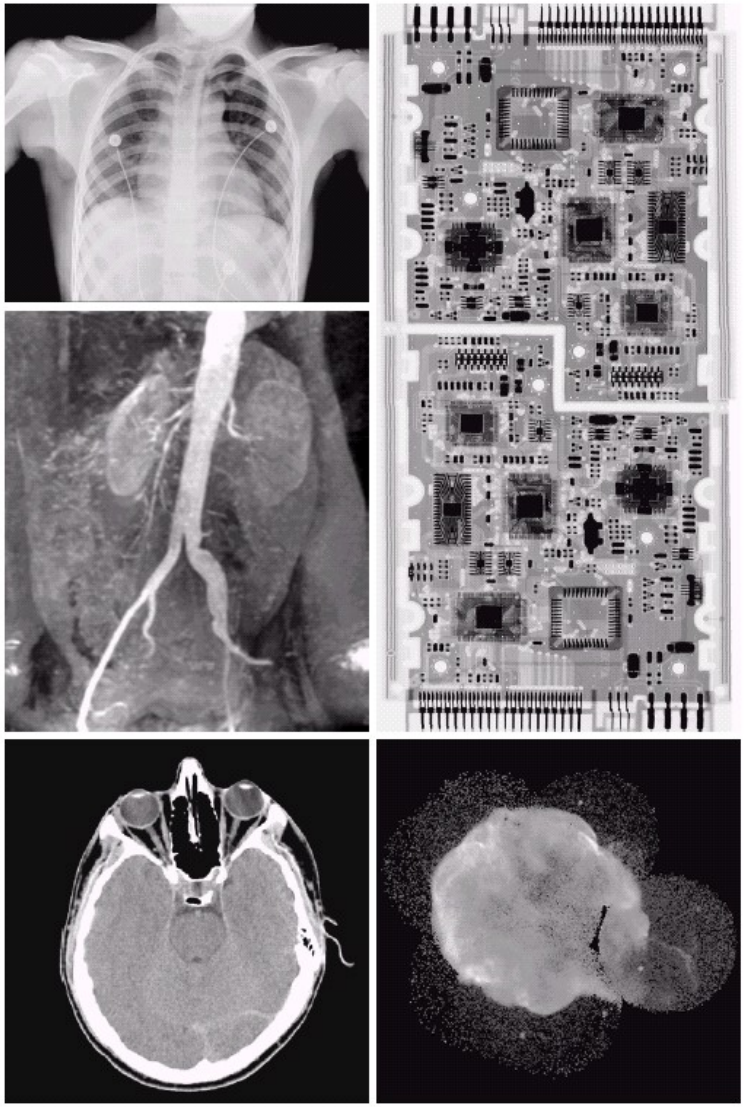
  λ **= 555nm, Green**

- **RGB color model**

- **3 component images**
  $f_r(m,n)$, $f_g(m,n)$, $f_b(m,n)$

4. Image from Invisible Light

- γ- ray imaging
- X- ray imaging
- Imaging in the ultraviolet band
- Imaging in the infrared band
- Imaging in the microwave band
- Imaging in the radio band

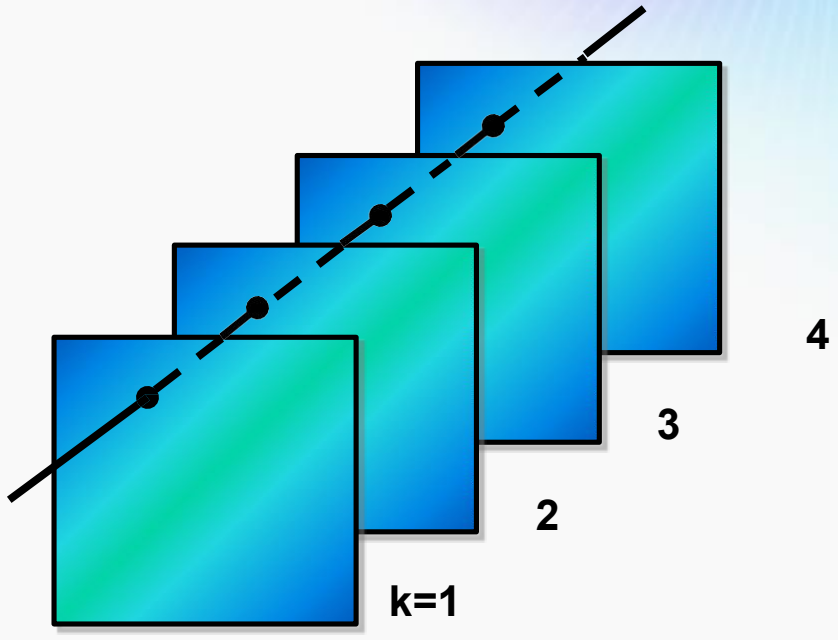


a d
b
c e

FIGURE 1.7 Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop. (Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University Medical Center, (b) Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School, (d) Mr. Joseph E. Pascente, Lixi, Inc., and (e) NASA.)

5. Spectrum Image

- $f_k(m,n)$, k=1…K
- Aeroplane/Satellite
- Spectrographic camera
- A wave band → A component image
- Object class recognition
- Image registration



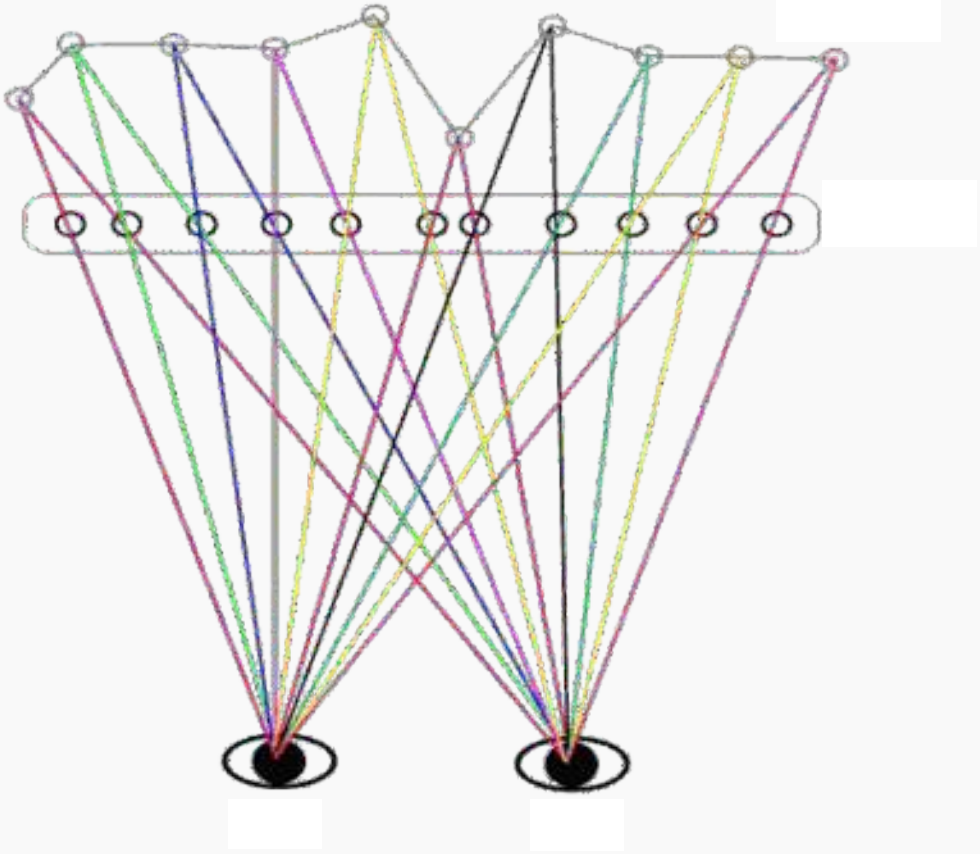
6. Moving Images (Video)

- Movie: 24 frames/second
- TV: 25 frames/second
- Gray scale image: $f_k(m,n)$
- Color image: $R_k(m,n)$, $G_k(m,n)$, $B_k(m,n)$

1st frame 2nd frame 3rd frame 4th frame 5th frame

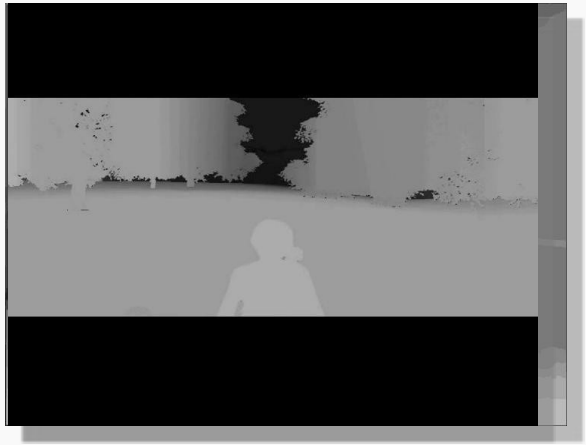
7. Stereovision

- **Left view + right view**



7. Stereovision (cont.)

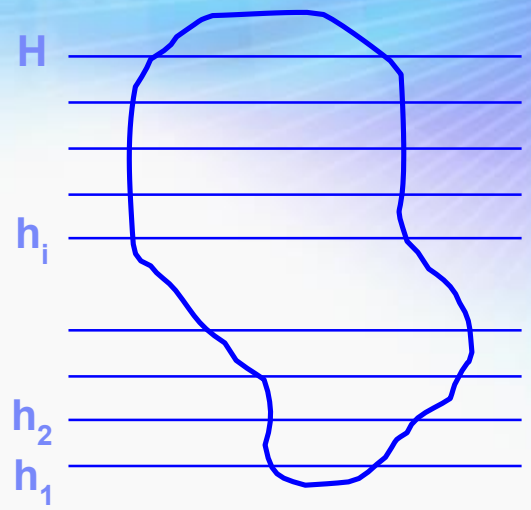
- Single view + depth map
- Stereo-camera
- Autonomous Land Vehicle (ALV)

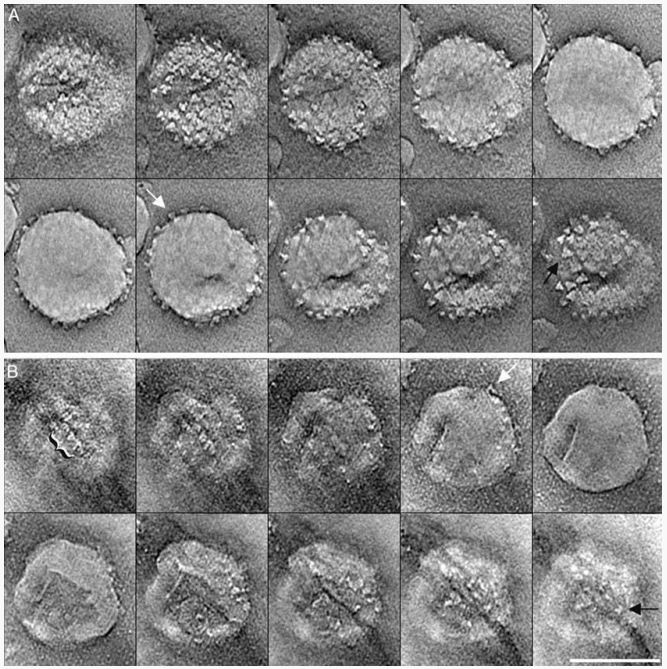


8. Tomogram Image

- Image reconstruction

- CT（Computerized Tomography）

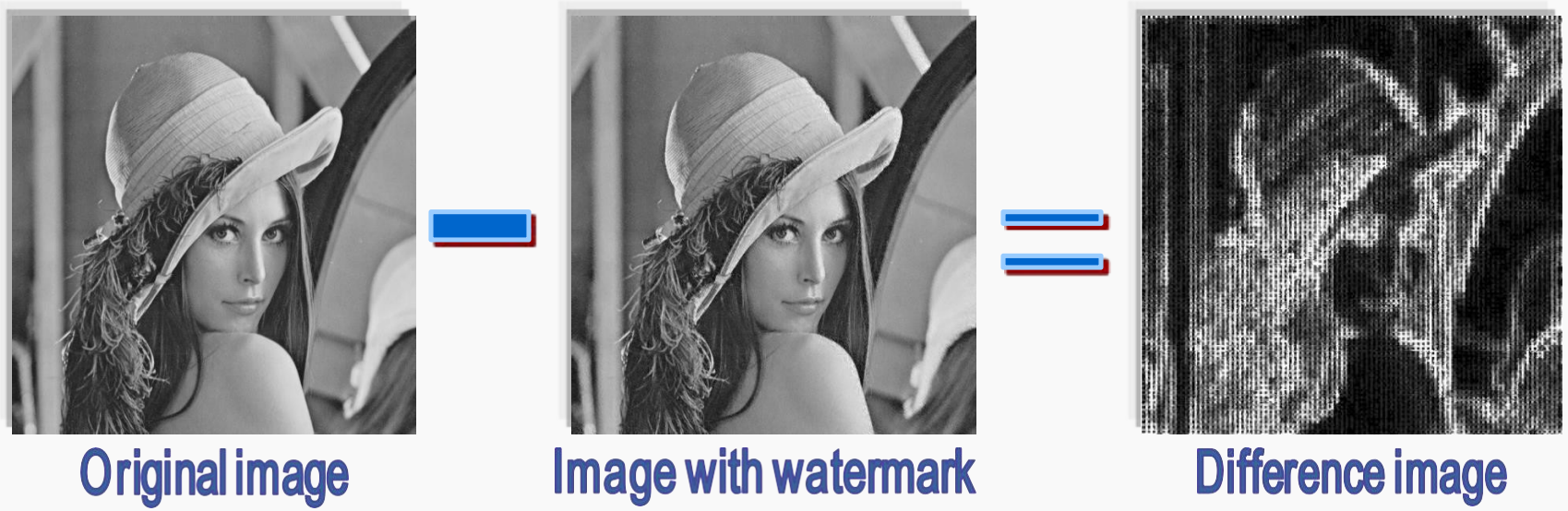




9. Image with Watermark

- Intellectual property protection

- Invisible differences (HVS)



C. Digital Image Processing

- **Low-level processing**

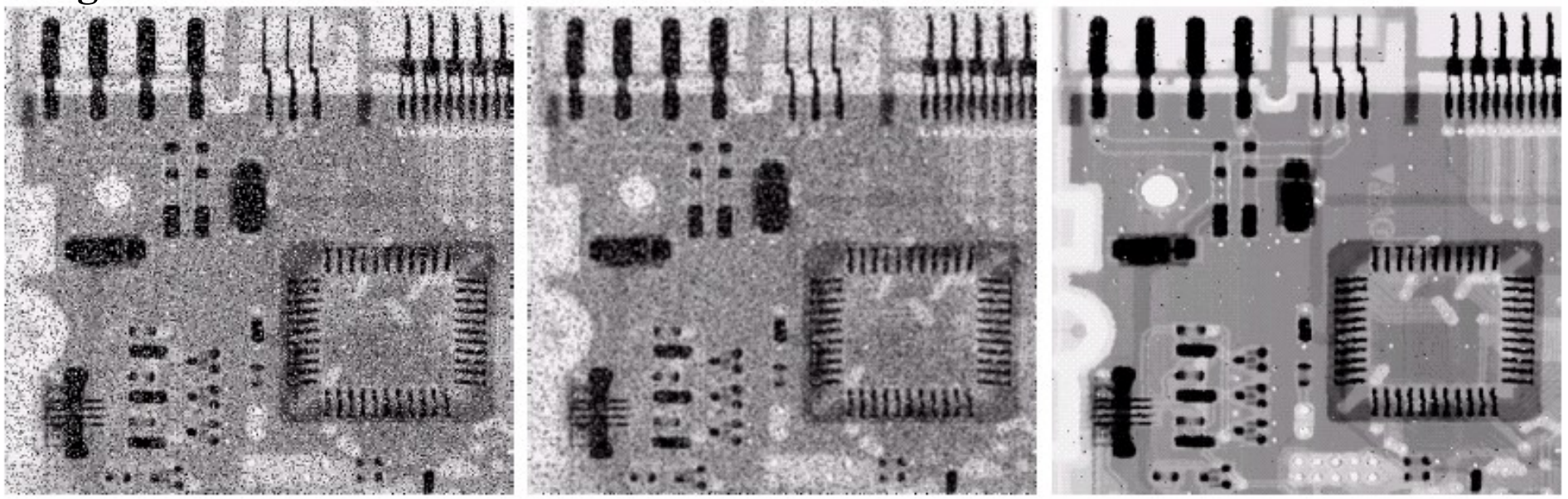
- **Pixel level**
- **Difficulties**
  - **-Real time**
  - **-Adjacent region**
  - **-Image segmentation**

Image enhancement

Image sharpening

Image enhancement

Denoising

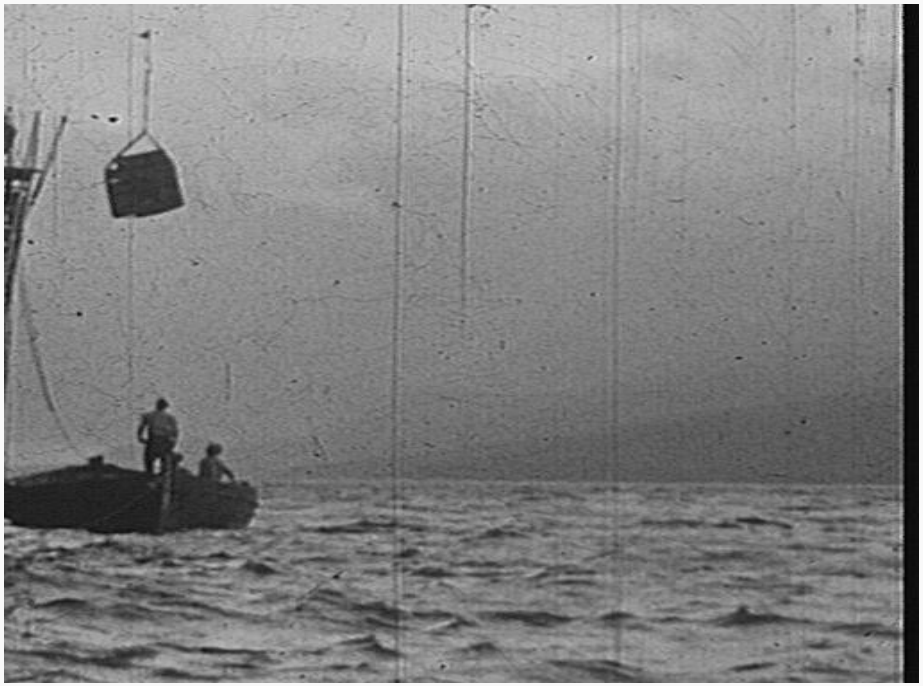


a b c

FIGURE 3.37 (a) X-ray image of circuit board corrupted by salt-and-pepper noise. (b) Noise reduction with a 3×3 averaging mask. (c) Noise reduction with a 3×3 median filter. (Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.)

Image enhancement

- Descratch



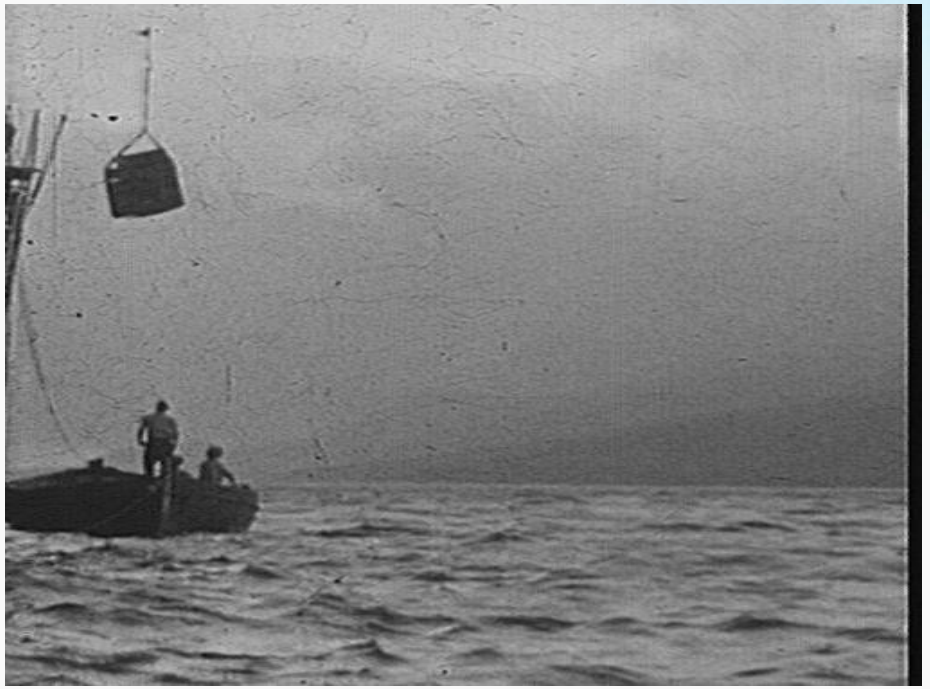


Image enhancement

- Homomorphic filtering

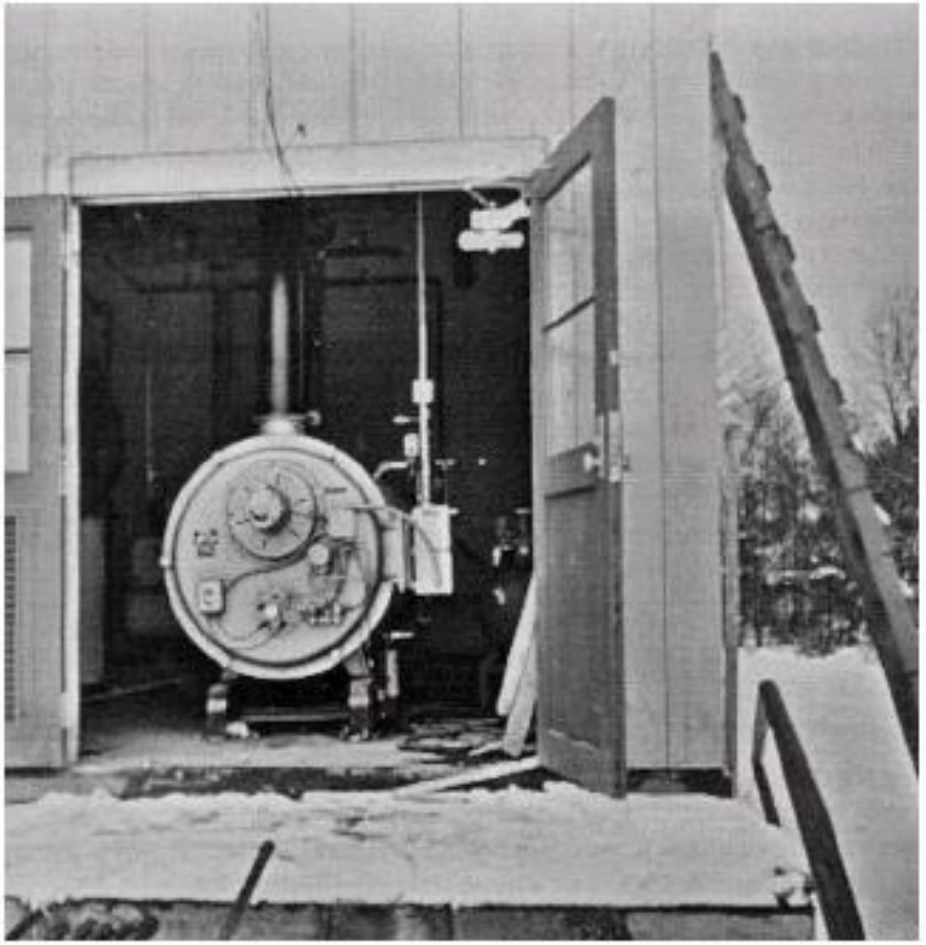
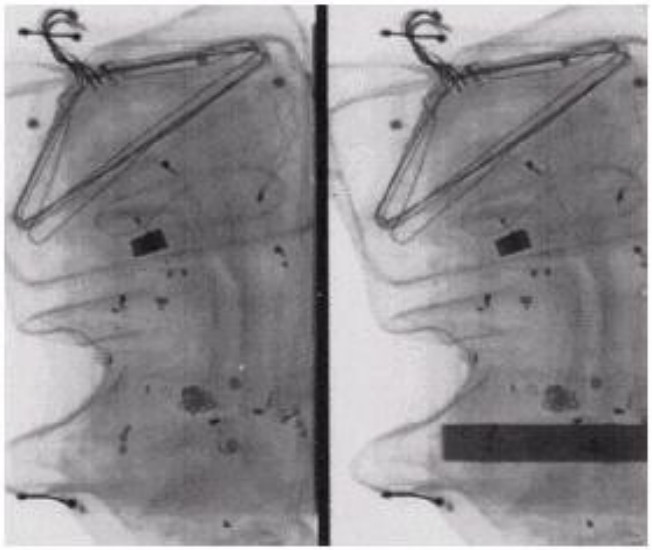


Image enhancement

- **Pseudocolor**



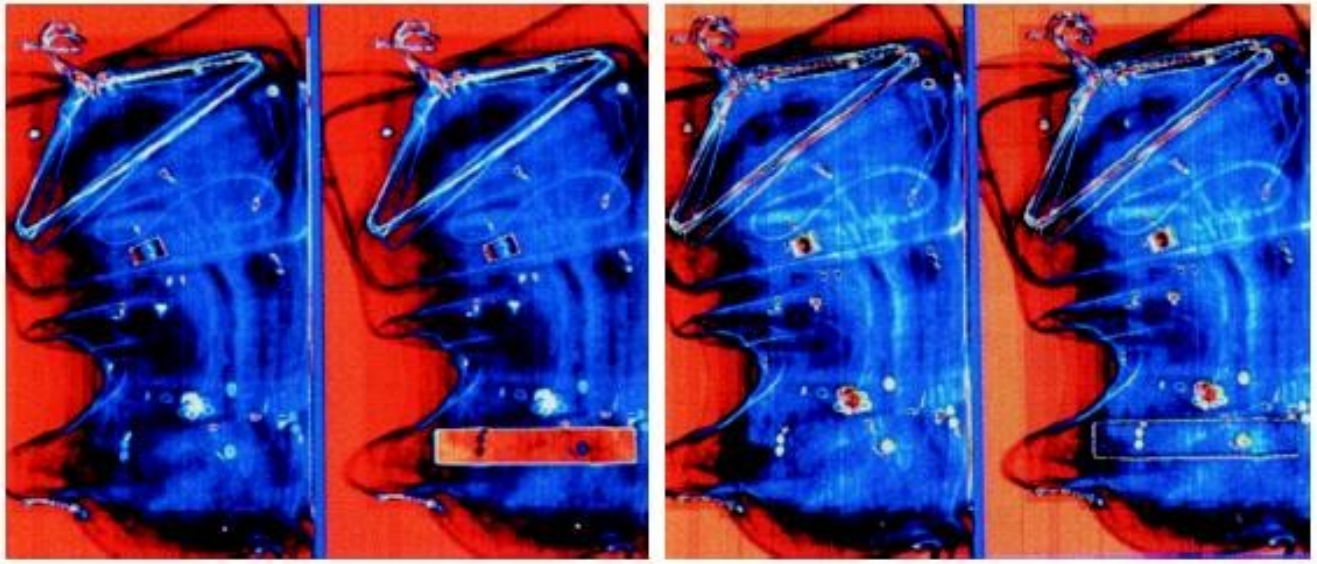


Image restoration

Original image

Blurred image

Restored image


Digital
Image
Processing
Digital
Image
Processing
Digital
Image
Processing
Digital
Image
Processing
Digital
Image
Processing

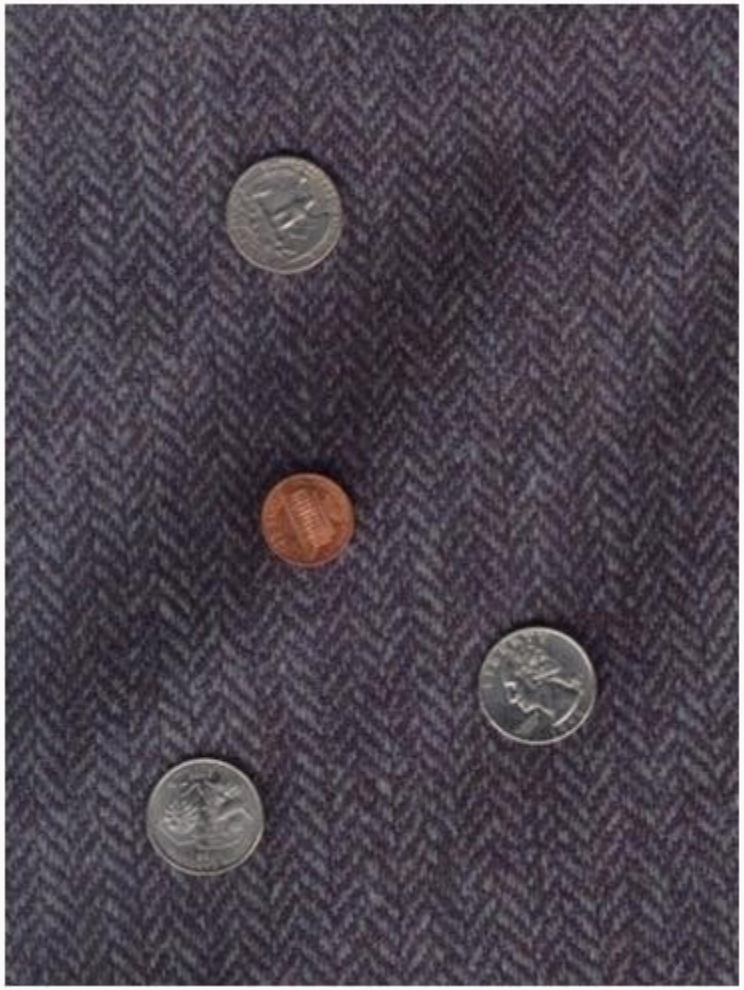
Image compression

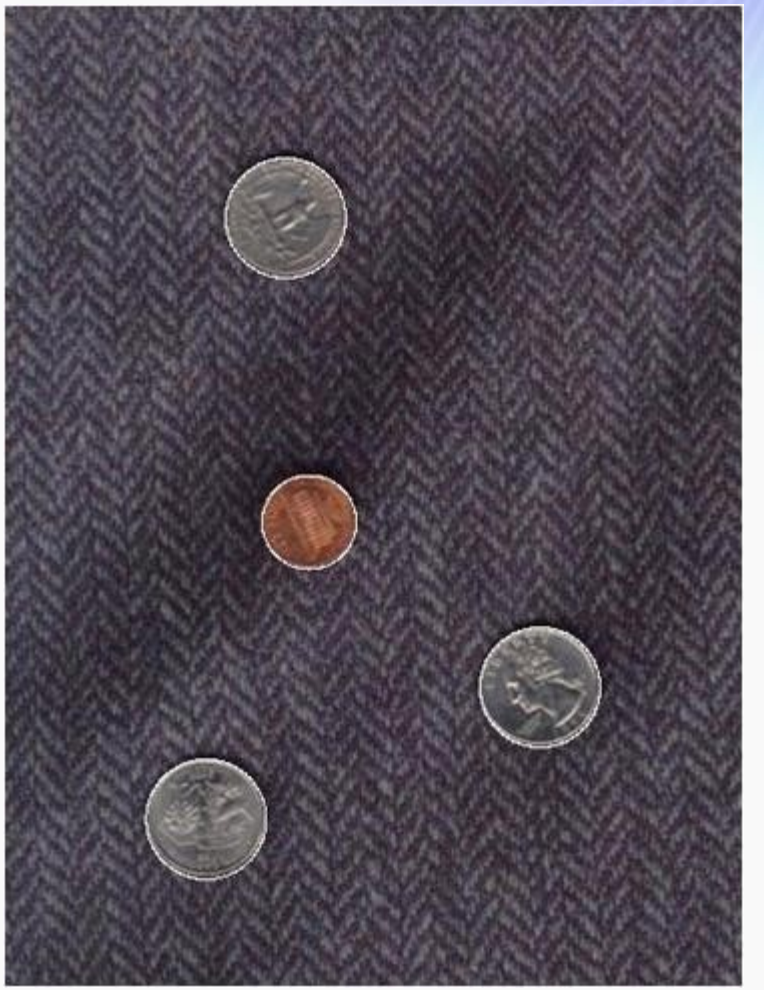
- **JPEG/JPEG2000**

(a) (b)

Compression at 0.25 b/p by means of (a) JPEG，(b) JPEG-2000

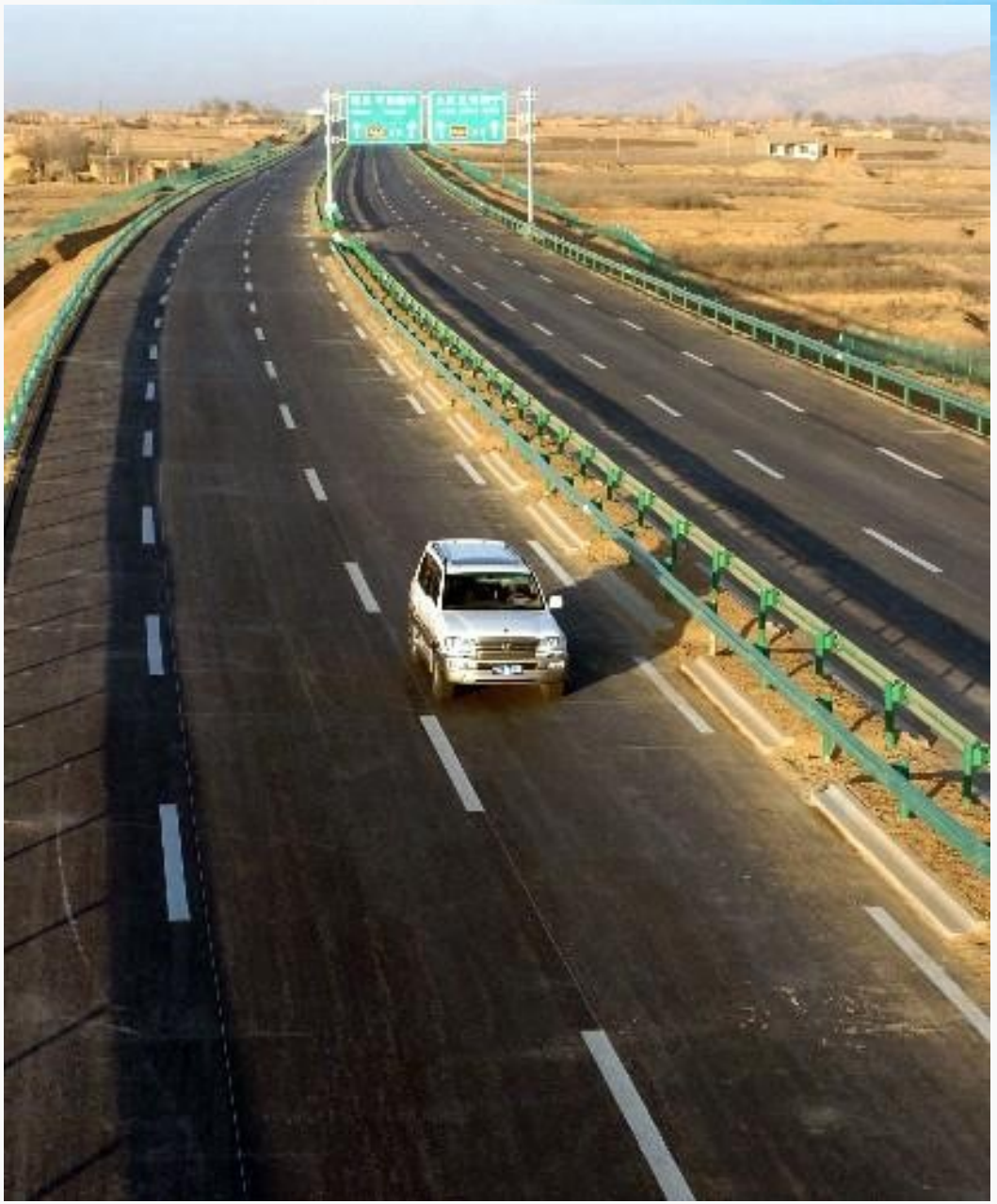
Image segmentation





▪ Middle-level & High-level processing

- **Image analysis, image recognition, image comprehension**
- **Pattern Recognition, Computer Vision**
- **Difficulty**
  - Computer has no intelligence



Moving object detection

Moving object detection

Event detection

- Free kick in soccer video

State 1→State 2→State 3→State 1

State 1 → State 2 → State 3 → State 1

Difficulties

1) Cognitive limitation of HVS (Human Visual System)
   - Objective image quality assessment
     - ✔ MSE, PSNR
   - Subjective image quality assessment
     - ✔ MOS (Mean Opinion Score)

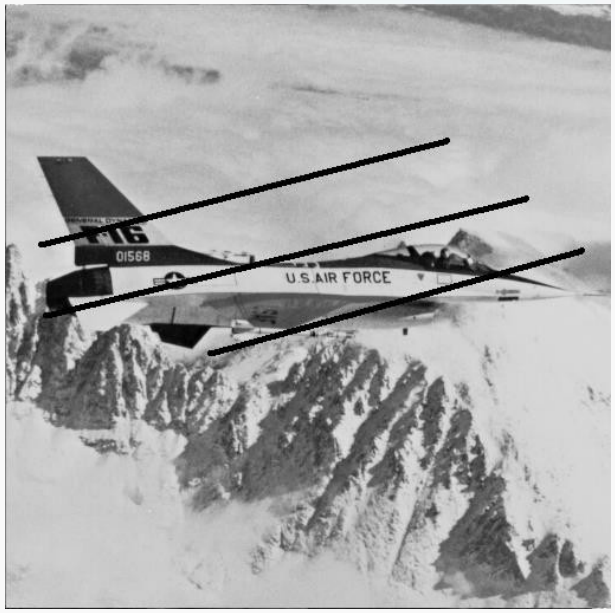
(a)

(b)

(c)

	MSE	PSNR
(b)	187.768	25.4526
(c)	188.7188	25.3727

(a)



(b)

(c)

	MSE	PSNR
(b)	704.1389	19.6542
(c)	1805.4317	15.565

Difficulties

1) Cognitive limitation of HVS (Human Visual System)
   - Objective image quality assessment
     ✔ MSE, PSNR
   - Subjective image quality assessment
     ✔ MOS (Mean Opinion Score)

2) Cognitive limitation of human perception mechanism
   - Image segmentation
   - Image recognition & comprehension

The most successful application —— Image Compression

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- Examples of Digital Image Processing
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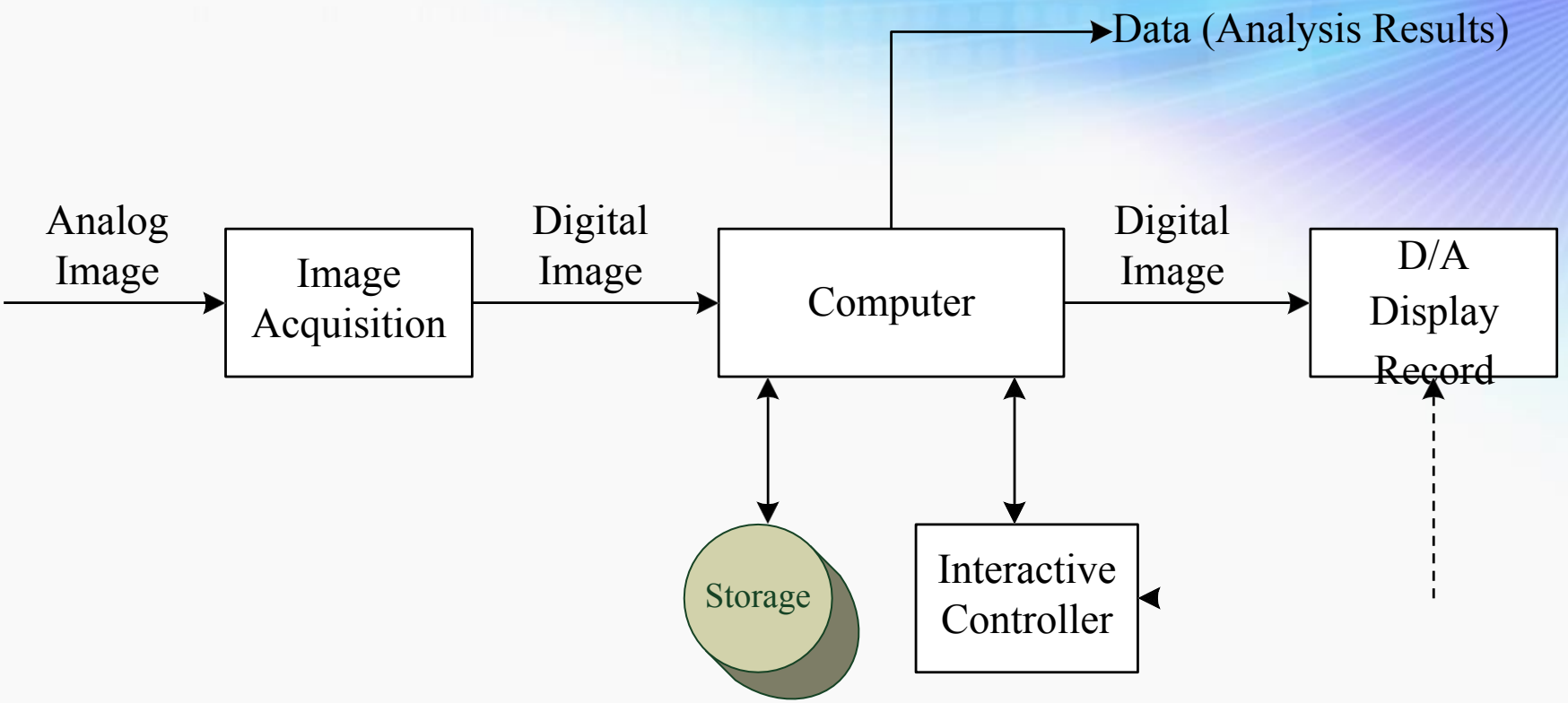
- **Components of an Image Processing System**



1. **Image Acquisition Equipment**
   - **DC**
   - **DV**
   - **Scanner**

2. **Computer**
   - **General (CPU/DSP)**
   - **Special (ASIC/SOC)**

Practice Exercise

Instructions:

Find another person as your partner. You'll have 5 minutes to discuss. Then introduce your partner to us in 1 minute.

- **Name**
- **Institute / Department**
- **Learning objectives / interests of this course**


Thank
You