

Prof Associate ,  
School of information engineering Jiangxi university of  
science and technology, China

EMAIL: [ajm@jxust.edu.cn](mailto:ajm@jxust.edu.cn)

# Digital Image Processing

## 数字图像处理



Lecture 02:  
Introduction to Digital  
Image Processing

Dr Ata Jahangir Moshayedi

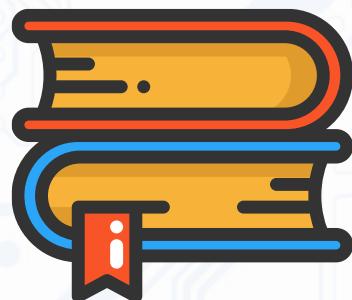
Spring \_2021



江西理工大学 信息工程学院

JIANGXI UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF INFORMATION ENGINEERING

Jiangxi University of Science and Technology



# Digital Image Processing

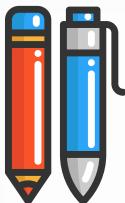
# 数字图像处理

**LECTURE 01:** Introduction to Digital Image Processing



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DR ajm lectures

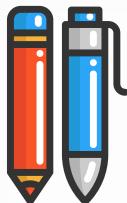


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DR AJM



# Our lecture on MOOC

All source about  
our course are  
available here

江西理工大学 Jiangxi University of Science and Technology  
信息工程学院 School of Information engineering

Digital Image Processing 数字图像处理

Dr. Ata Jahangir Moshayedi

Prof Associate -  
School of information engineering, Jiangxi University of  
science and technology, China

EMAIL: ajm@jxust.edu.cn

Spring \_2021

数字图像处理(DIP 2021)  
ATAJAHANGIR MOSHAYEDI  
江西理工大学  
课程编号: Digital Image Processing

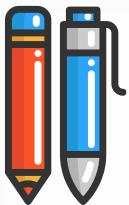
Invitation Code: **35647105**

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# Contents



- What is a digital image?
- What is digital image processing?
- History of digital image processing

什么是数字图像?

什么是数字图像处理?

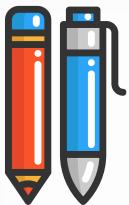
数字图像处理的历史

Shénme shì shùzì túxiàng?

Shénme shì shùzì túxiàng chǔlǐ?

Shùzì túxiàng chǔlǐ de lìshǐ



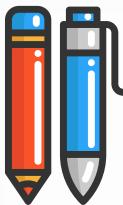


# Types Of Methods Used For Image Processing



- There are two types of methods used for image processing namely, analog and digital image processing.  
**模拟图像 mó nǐ tú xiàng**
- Analog image processing can be used for hard copies like **printouts** and **photographs**.
- Digital image processing techniques help in the **manipulation** of digital images by  
**数字图像 shù zì tú xiàng**





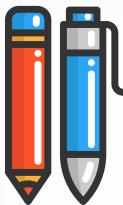
# What is a Digital Image?(cont...)



什么是数字图像?

- The range of the colors in 8 bit vary
- from 0–255 where:
  - 0 — black
  - 255 — white
  - 127 — grey colour. 灰色 Huīsè





# What is a Digital Image?(cont...)



Common image formats include (常见图片样式包括有) :

- 1 sample per point (B&W or Grayscale) 每点1个采样 (黑白或灰度)
- 3 samples per point (Red, Green, and Blue)
- 4 samples per point (Red, Green, Blue, and “Alpha”, a.k.a. Opacity)

“Alpha” , 也称为不透明度

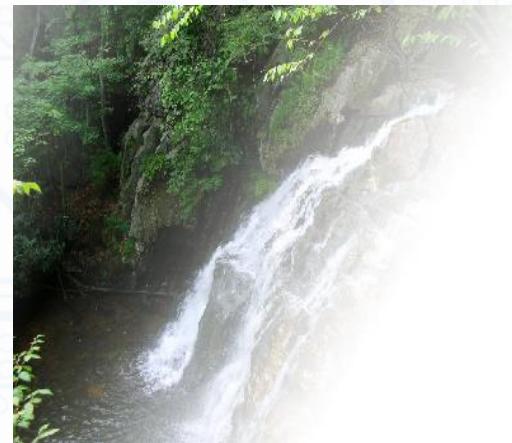
For most of this Course we will focus on grey-scale images



Grayscale

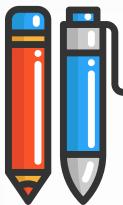


RGB



RGBA





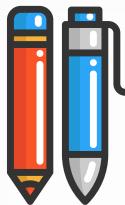
# What is a black and white image?

什么是黑白图像？



- The image consists of **black** and **white color** only.





# What are greyscale images?

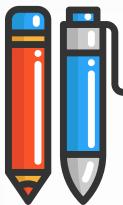


灰度图像 **huidutuxiang**

- It is a black and white image, but the name emphasizes that such an image will also include many **shades of grey**.
- The values ranging between **0 and 255**.

灰色阴影 **huī sè yīn yǐng**





# What is Digital Image Processing?



Digital image processing focuses on two major tasks

- Improvement of pictorial information for human interpretation
- Processing of image data for storage, transmission and representation for autonomous machine perception

Some argument about where image processing ends and fields such as image analysis and computer vision start

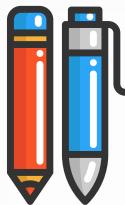
-提高人类对图像信息的解读

tí gāo rén lèi duì tú xiàng xìn xī de jiě dù

-用于自动机器感知的存储、传输和表示的图像数据处理

yòng yú zì dòng jī qì gǎn zhī de cún chǔ 、 chuán shū hé biǎo shì de tú xiàng shù jù chù lǐ





# Why do we process images?



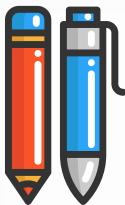
- It has been developed to deal with 3 major problems —
- To improve the **image** data to suppress the unwanted distortions.

提高

- To **enhance** some features of the input **image**.
- As a means of translation between the **human visual system** and **digital imaging devices**. 数码影像设备

人类视觉系统





# What is image Processing?



算法

Algorithms that alter an input image to create new image  
Input is image, output is image

- Improves an image for human interpretation in ways including:

- Image display and printing
- Image editing
- Image enhancement
- Image compression

- 图像显示和打印
- 图像编辑
- 图像增强
- 图像压缩



Original Image

原图 Yuán tú

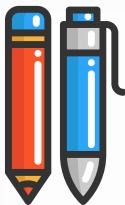
Image Processing  
Algorithm  
(e.g. Sobel Filter)



Processed Image

处理后的图像 chǔlǐ hòu de túxiàng





# Example Operation:



噪声图像

zào shēng tú xiàng

去噪图像 Qù zào túxiàng

Noisy Image



Denoised Image

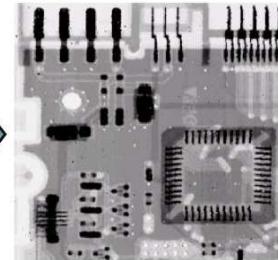
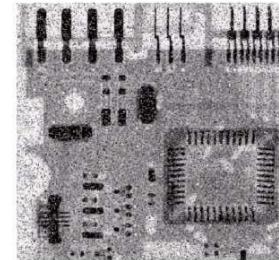
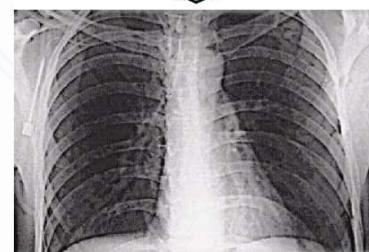
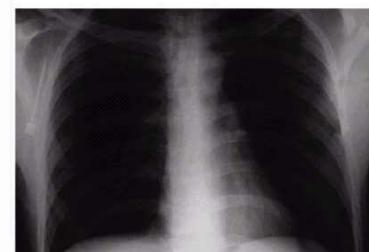


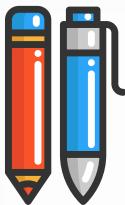
Noise Removal

降噪 Jiàng zào

Noise Removal

Think of noise as white specks on a picture  
(random or non-random)





# Example Operation:



## Contrast Adjustment

对比度调整  
Duìbǐdù tiáozhěng



Low Contrast

低对比度 Dī duìbǐdù

Original Contrast

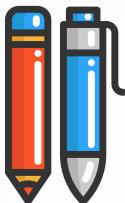
High Contrast

高对比度 Gāo duìbǐdù

## Edge Detection

边缘检测  
Biānyuán jiǎncè



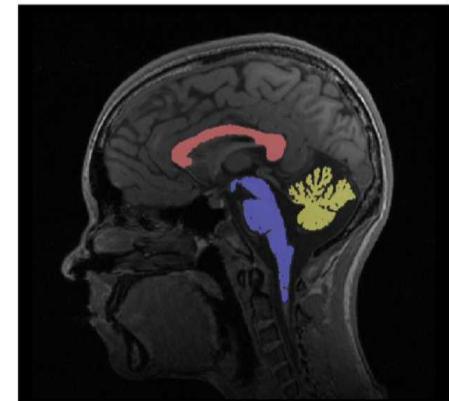
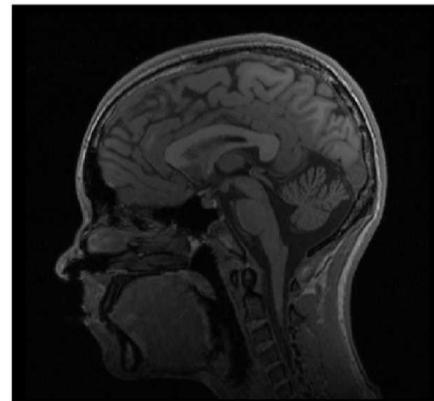


# Example Operation:



## Region Detection, Segmentation

区域检测、分割  
Qūyù jiǎncè, fēngē



## Image Compression

图像压缩  
Túxiàng yāsuō

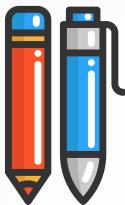


Original, 2.1MB



JPEG Compression, 308KB (15%)





# What is DIP? (cont...)



The continuum from image processing to computer vision can be broken up into low-, mid- and high-level processes

低、中、高级流程 Dī, zhōng, gāojí liúchéng

## Low Level Process

**Input:** Image

**Output:** Image

**Examples:** Noise removal, image sharpening

## Mid Level Process

**Input:** Image

**Output:** Attributes

**Examples:** Object recognition, segmentation

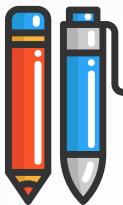
## High Level Process

**Input:** Attributes

**Output:** Understanding

**Examples:** Scene understanding, autonomous navigation

In this course we will stop here



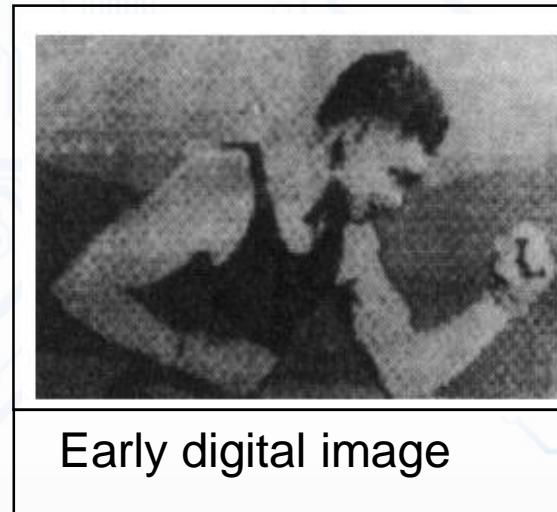
# History of Digital Image Processing

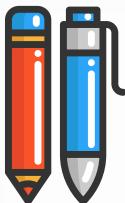
数字图像处理的历史 Shùzì túxiàng chǔlǐ de lìshǐ



**Early 1920s:** One of the first applications of digital imaging was in the news-paper industry

- The Bartlane cable picture transmission service
- Images were transferred by submarine cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer





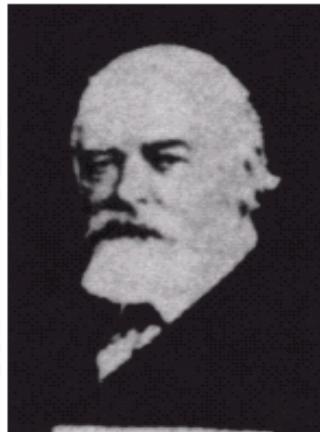
# History of DIP (cont...)

数字图像处理的历史 Shùzì túxiàng chǔlǐ de lìshǐ



**Mid to late 1920s:** Improvements to the Bartlane system resulted in higher quality images

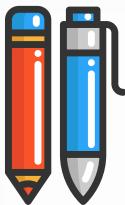
- New reproduction processes based on photographic techniques
- Increased number of tones in reproduced images



Improved digital image



Early 15 tone digital image



# History of DIP (cont...)

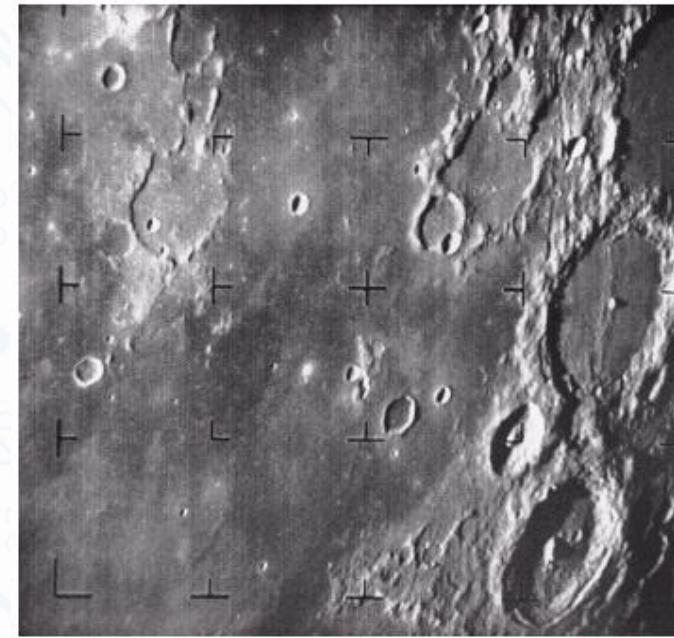
数字图像处理的历史 Shùzì túxiàng chǔlǐ de lìshǐ



**1960s:** Improvements in computing technology and the onset of the space race led to a surge of work in digital image processing

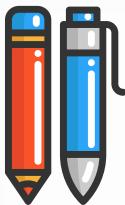
**1964:**

- Computers used to improve the quality of images of the moon taken by the *Ranger 7* probe
- Such techniques were used in other space missions including the Apollo landings



A picture of the moon taken by the Ranger 7 probe minutes before landing





# History of DIP (cont...)

数字图像处理的历史 Shùzì túxiàng chǔlǐ de lìshǐ



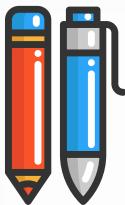
**1970s:** Digital image processing begins to be used in medical applications

**1979:** Sir Godfrey N. Hounsfield & Prof. Allan M. Cormack share the Nobel Prize in medicine for the invention of tomography, the technology behind Computerised Axial Tomography (CAT) scans



Typical head slice CAT image





# History of DIP (cont...)



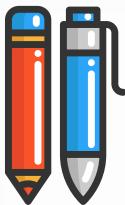
## 1980s - Today:

The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas

- Image enhancement/restoration
- Artistic effects
- Medical visualisation
- Industrial inspection
- Law enforcement
- Human computer interfaces

-图像增强/恢复	tú xiàng zēng qiáng / huī fù
-艺术效果	yì shù xiào guǒ
-医学可视化	yī xué kě shì huà
-工业检验	gōng yè jiǎn yàn
-执法	zhí fǎ
-人机界面	rén jī jiè miàn



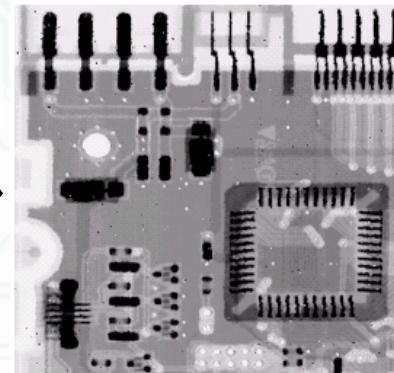
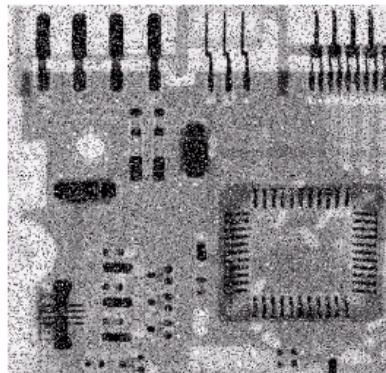
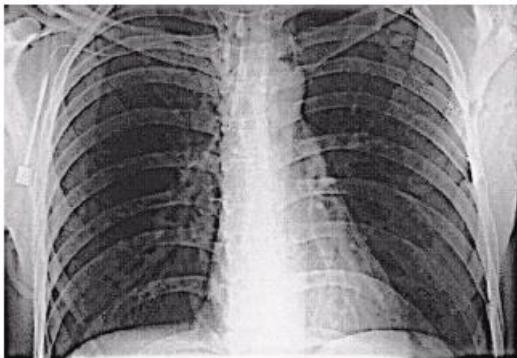
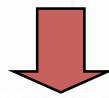


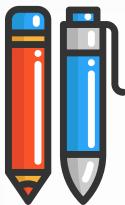
# Examples: Image Enhancement

图像增强 Túxiàng zēngqiáng



One of the most common uses of DIP techniques:  
improve quality, remove noise etc





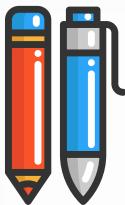
# Examples: The Hubble Telescope

艺术效果 ...Yishù xiàoguǒ



Launched in 1990 the Hubble telescope can take images of very distant objects. However, an incorrect mirror made many of Hubble's images useless. Image processing techniques were used to fix this.



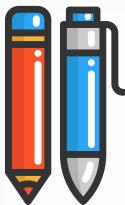


# Examples: Artistic Effects

艺术效果 Yishù xiàoguǒ

Artistic effects are used to make images more visually appealing, to add special effects and to make composite images





# Examples: Medicine



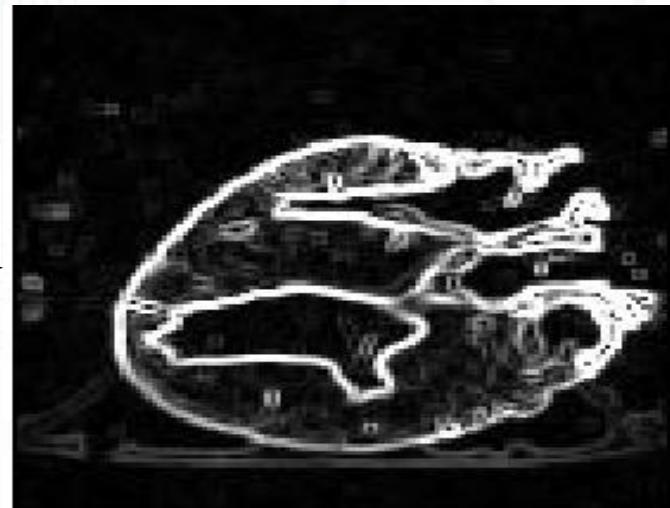
医学 yī xué

Take slice from MRI scan of canine heart, and find boundaries between types of tissue

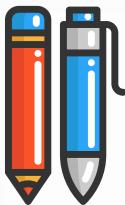
- Image with gray levels representing tissue density
- Use a suitable filter to highlight edges



Original MRI Image of a Dog Heart



Edge Detection Image



# Examples: GIS

地理信息系统 Dìlǐ xìnxī xìtǒng

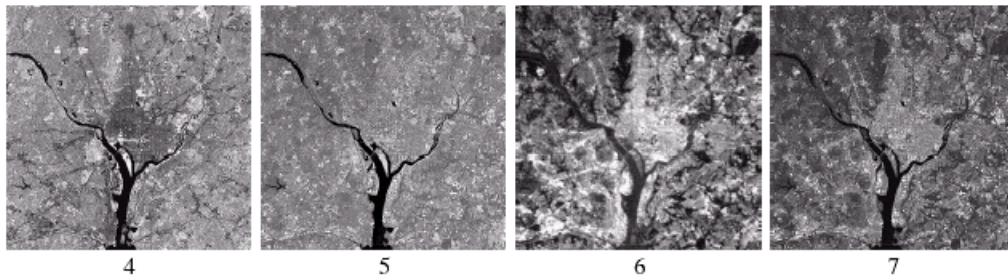
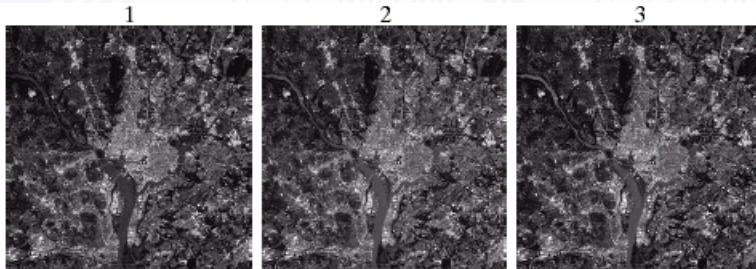


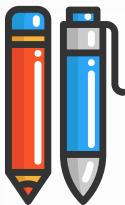
## Geographic Information Systems

地理信息系统 Dìlǐ xìnxī xìtǒng

- Digital image processing techniques are used extensively to manipulate satellite imagery
- Terrain classification
- Meteorology

气象 Qìxiàng



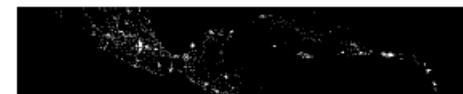


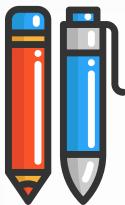
# Examples: GIS (cont...)



## *Night-Time Lights of the World* data set

- Global inventory of human settlement
- Not hard to imagine the kind of analysis that might be done using this data





# Examples: Industrial Inspection

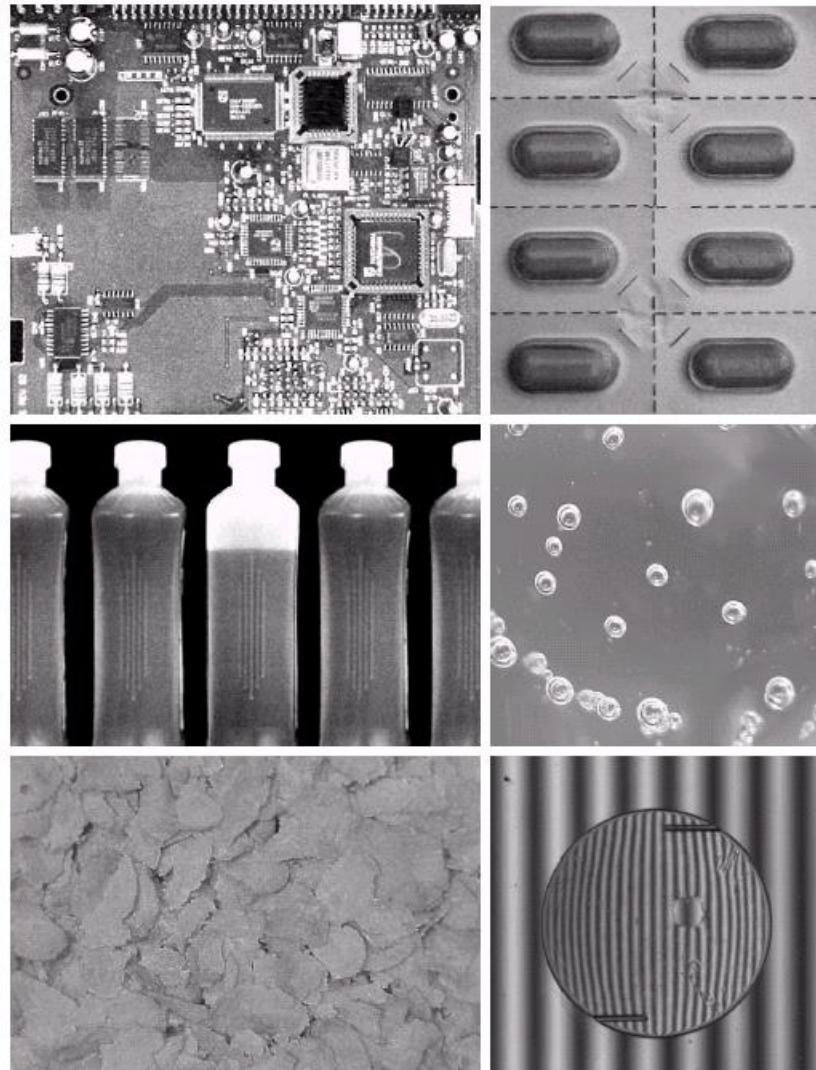
工业检验 Gōngyè jiǎnyàn

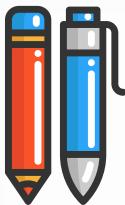
Human operators are expensive,  
slow and unreliable

Make machines do the  
job instead

Industrial vision systems  
are used in all kinds of industries

Can we trust them?





# Examples: PCB Inspection

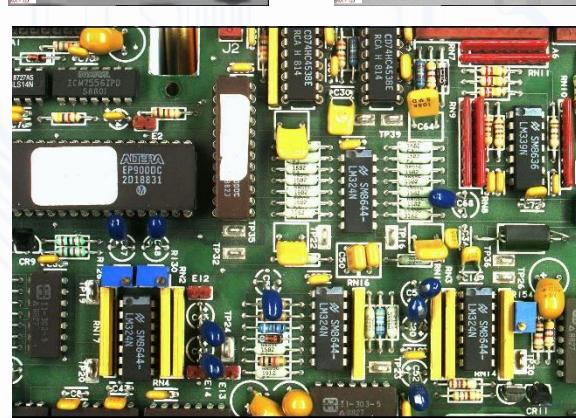
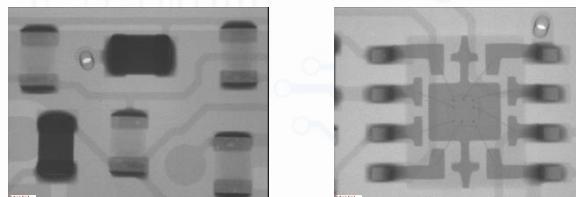


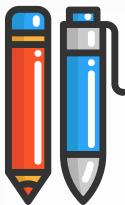
印刷电路板（PCB）检查

yìn shuā diàn lù bǎn jiǎn chá

## Printed Circuit Board (PCB) inspection

- Machine inspection is used to determine that all components are present and that all solder joints are acceptable
- Both conventional imaging and x-ray imaging are used



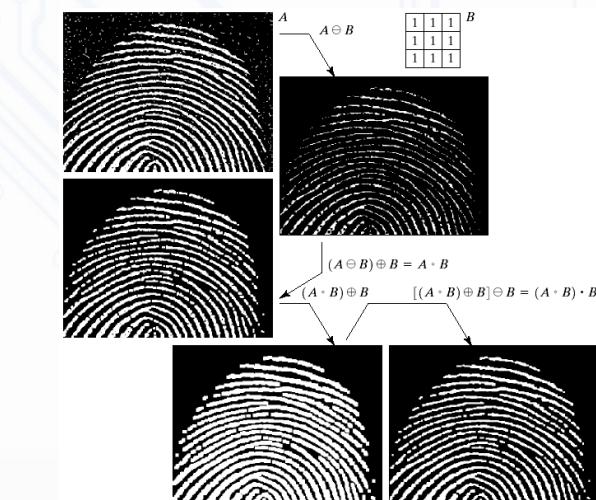


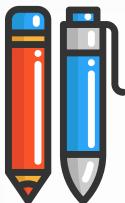
# Examples: Law Enforcement

执法 Zhífǎ

Image processing techniques are used extensively by law enforcers

- Number plate recognition for speed cameras/automated toll systems
- Fingerprint recognition
- Enhancement of CCTV images





# Examples: HCI(HUMAN COMPUTER INTERFACES)

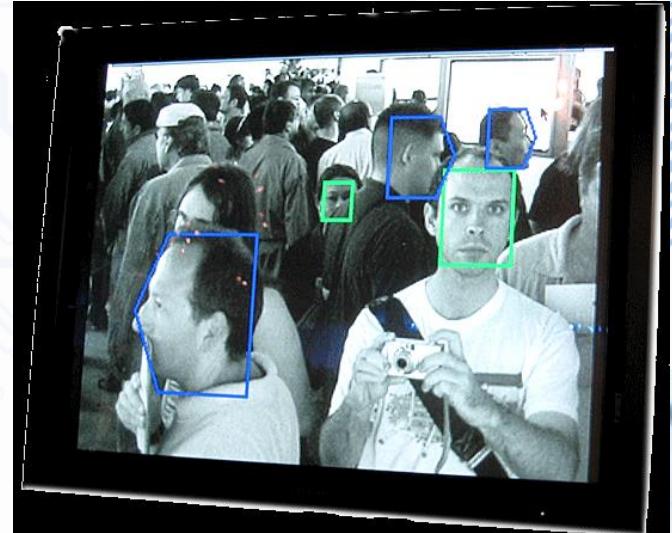
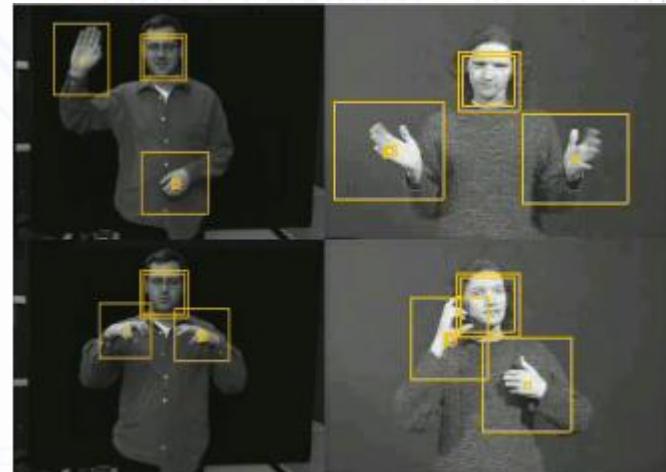
人机界面 Rén jī jièmiàn



Try to make human computer interfaces more natural

- Face recognition
- Gesture recognition

人脸识别  
手势识别  
Rén liǎn shìbìé  
shǒushì shìbìé

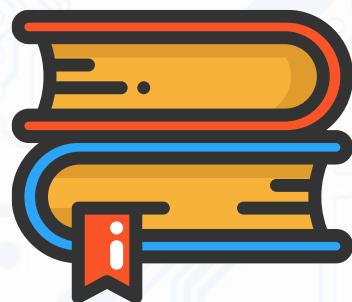




江西理工大学 信息工程学院

JIANGXI UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF INFORMATION ENGINEERING

Jiangxi University of Science and Technology



# Digital Image Processing

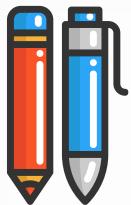
# 数字图像处理

**LECTURE 03-B: Introduction to Digital Image Processing**



江西理工大学 信息工程学院  
JIANGXI UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF INFORMATION ENGINEERING





# Contents



- What is digital image processing?
- Key stages in digital image processing

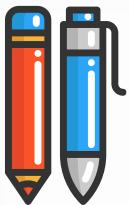
什么是数字图像处理？

Shénme shì shùzì túxiàng chǔlǐ?

数字图像处理的关键阶段

Shùzì túxiàng chǔlǐ de guānjiàn jiēduàn



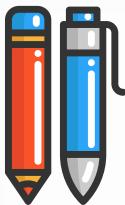


# Image Processing :

图像处理 : Túxiàng chǔlǐ:



- Image processing is a **method to convert an image into digital form and perform some operations on it**, in order to get an enhanced image or to extract some useful information from it.
- It is a type of signal dispensation in which input is an image, like video frame or photograph and output may be image or characteristics associated with that image.
- Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them.



# Purpose of Image processing



The purpose of image processing is divided into 5 groups.

They are :

- **Visualization** - Observe the objects that are not visible.
- **Image sharpening and restoration** - To create a better image.
- **Image retrieval** - Seek for the image of interest.
- **Measurement of pattern** – Measures various objects in an image.
- **Image Recognition** – Distinguish the objects in an image.

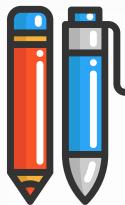
可视化 - 观察不可见的对象。

图像锐化和恢复 - 创建更好的图像。

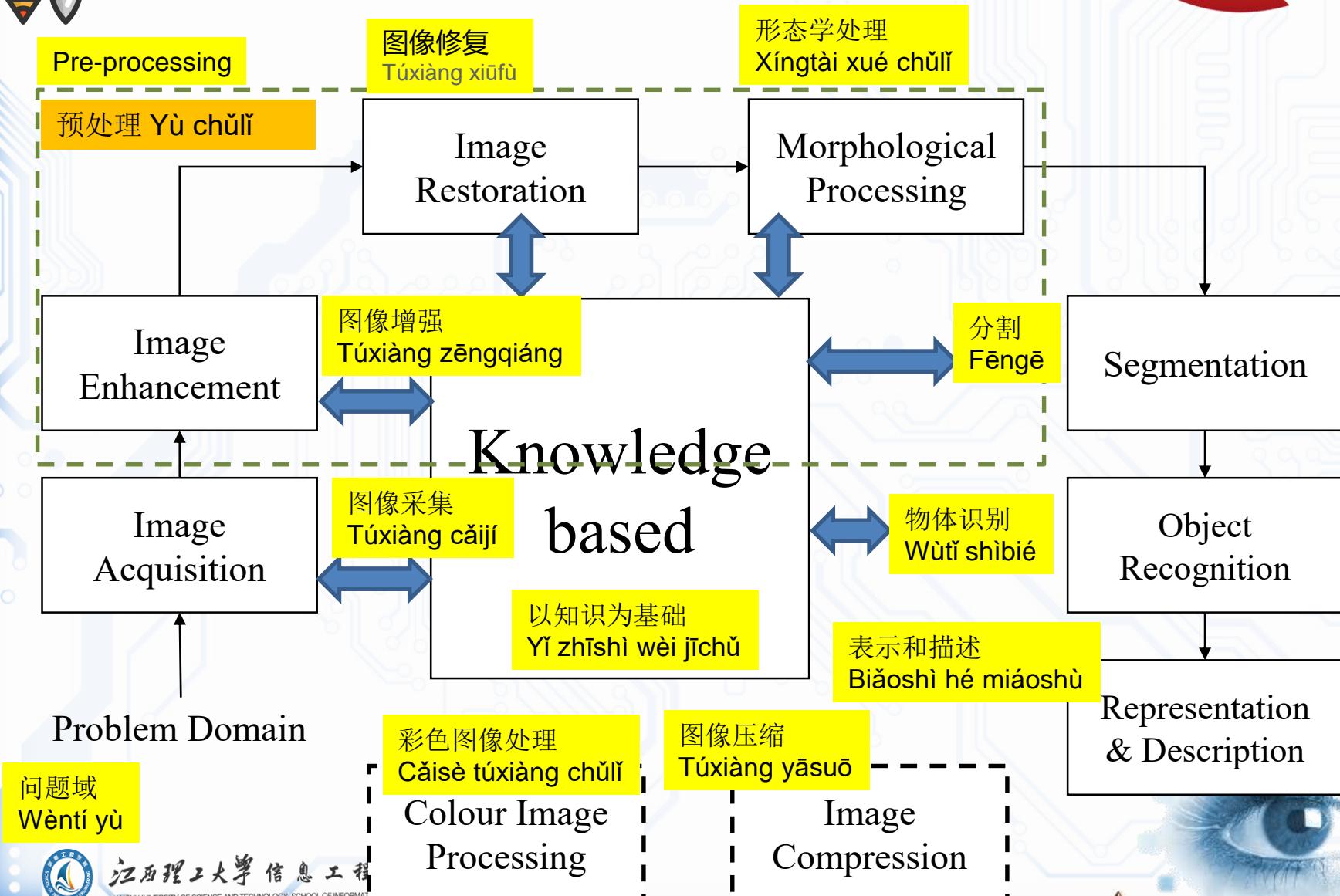
图像检索 - 寻找感兴趣的图像。

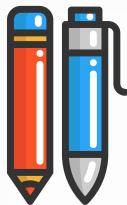
图案测量 - 测量图像中的各种对象。

图像识别 - 区分图像中的对象。

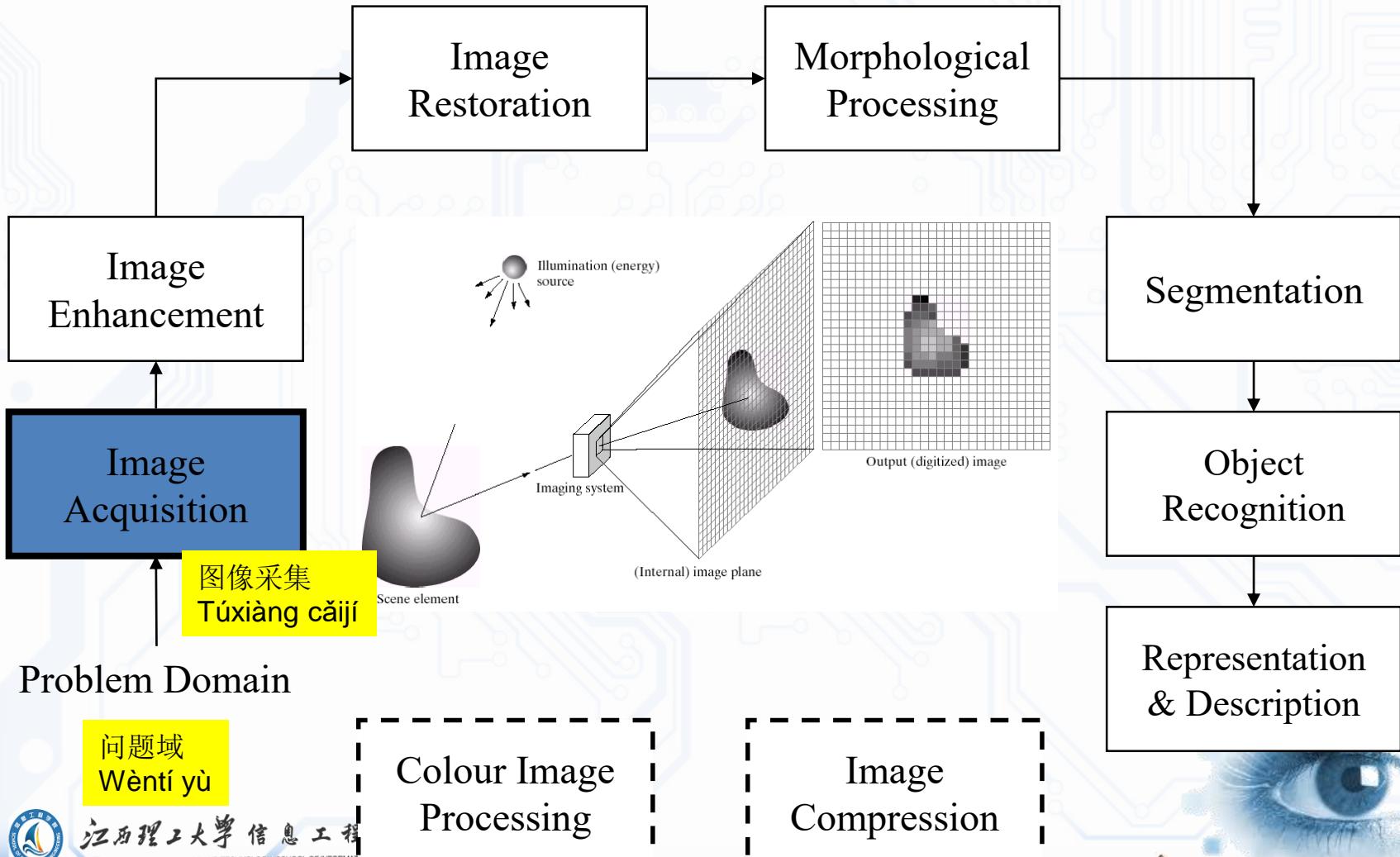


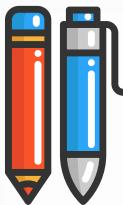
# Key Stages in Digital Image Processing





# Key Stages in Digital Image Processing: Image Acquisition





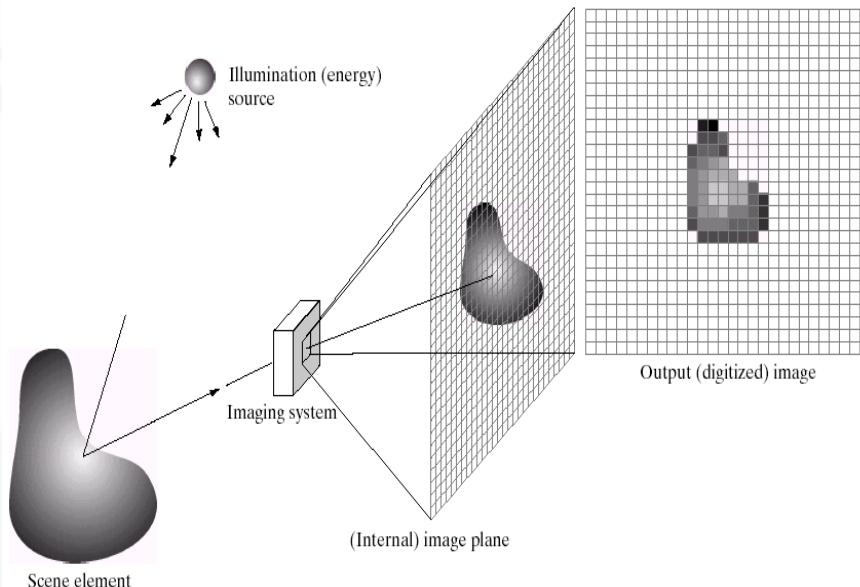
# Fundamental Steps in DIP



## 1. Image Acquisition

图像采集 Túxiàng cǎijí

- This is the first step or process of the fundamental steps of digital image processing.
- Image acquisition could be as simple as being given an image that is already in digital form.
- Generally, the image acquisition stage involves pre-processing, such as scaling etc.

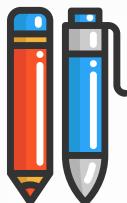


### Image Acquisition

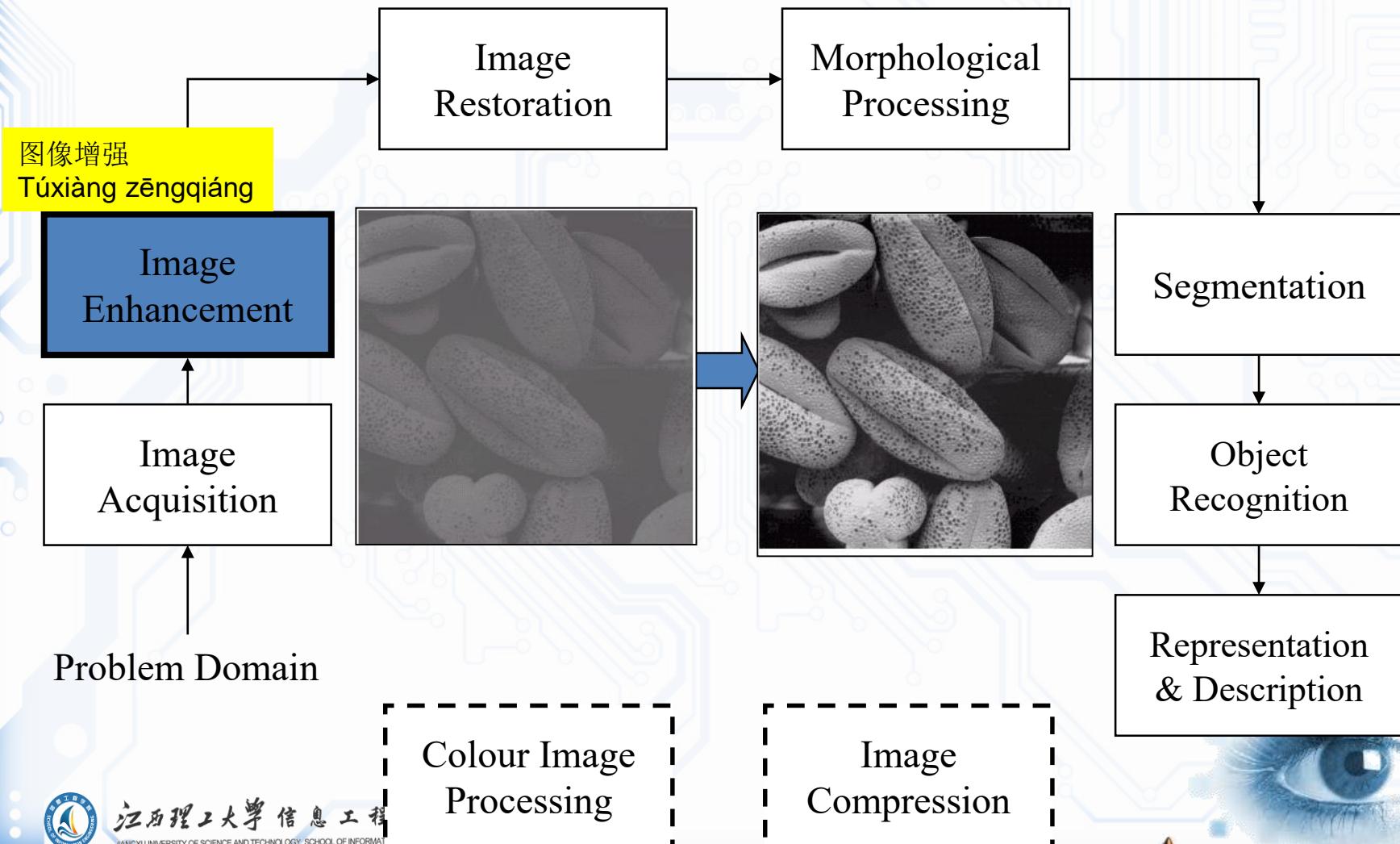
- It is basically **capturing an image**.
- Generally, the image acquisition stage involves **pre-processing**, such as scaling, etc.

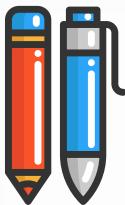
预处理  
Yù chǔlǐ





# Key Stages in Digital Image Processing: Image Enhancement



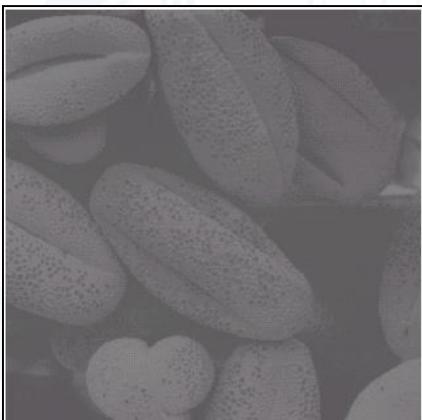


# 2. Image Enhancement

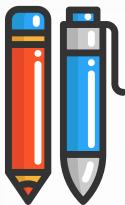
图像增强  
Túxiàng zēngqiáng



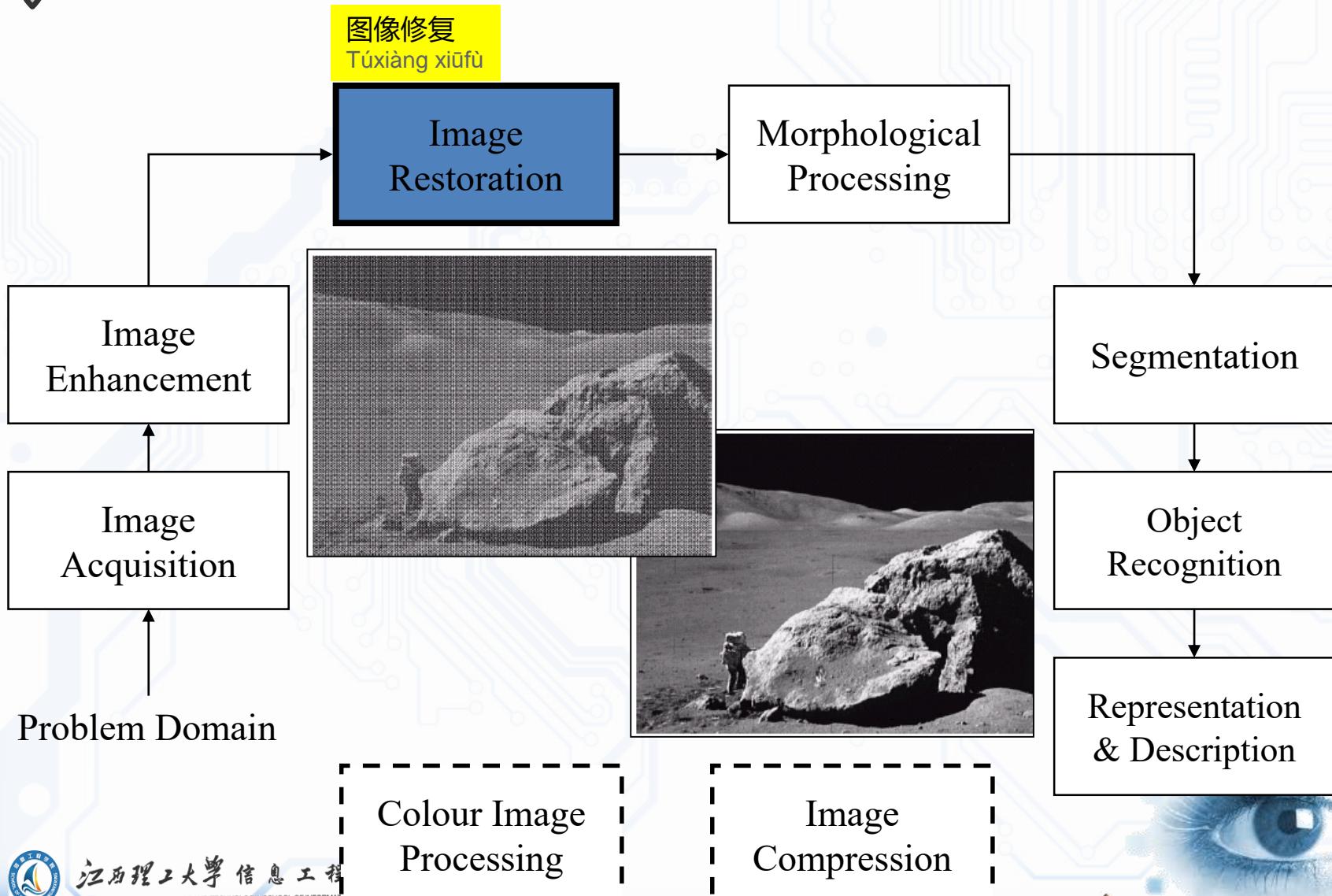
- Image enhancement is among the simplest and most appealing areas of digital image processing.
- Basically, the idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image. Such as, changing brightness & contrast etc.

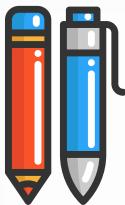


• It is the process of **filtering** **image**(removing noise, increasing contrast, etc) to **improve the quality**.  
• The resulting image will be more suitable than the **original image**.



# Key Stages in Digital Image Processing: Image Restoration





# 3. Image Restoration

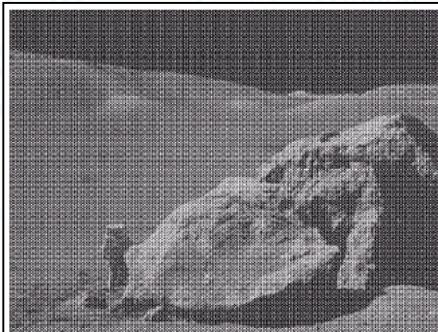
图像修复

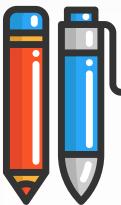
Túxiàng xiūfù



- Image restoration is an area that also deals with improving the appearance of an image. 改善图像的外观。Gǎishàn túxiàng de wàiguān.
- However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.

it is the process of **improving appearance** (reducing blurring etc) of an image by **mathematical or probabilistic models**.

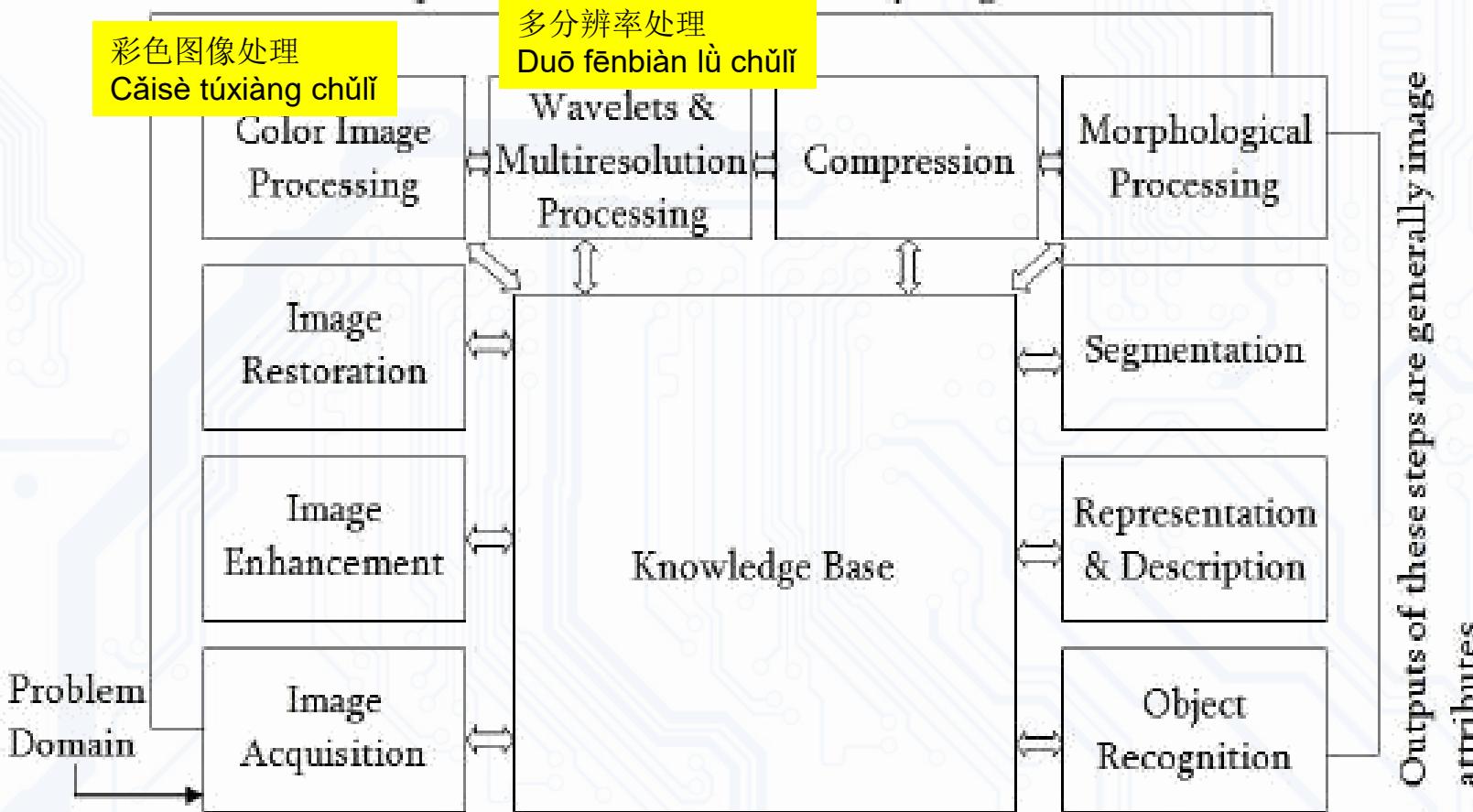




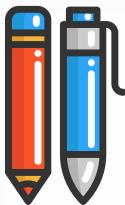
# Fundamental Steps in DIP



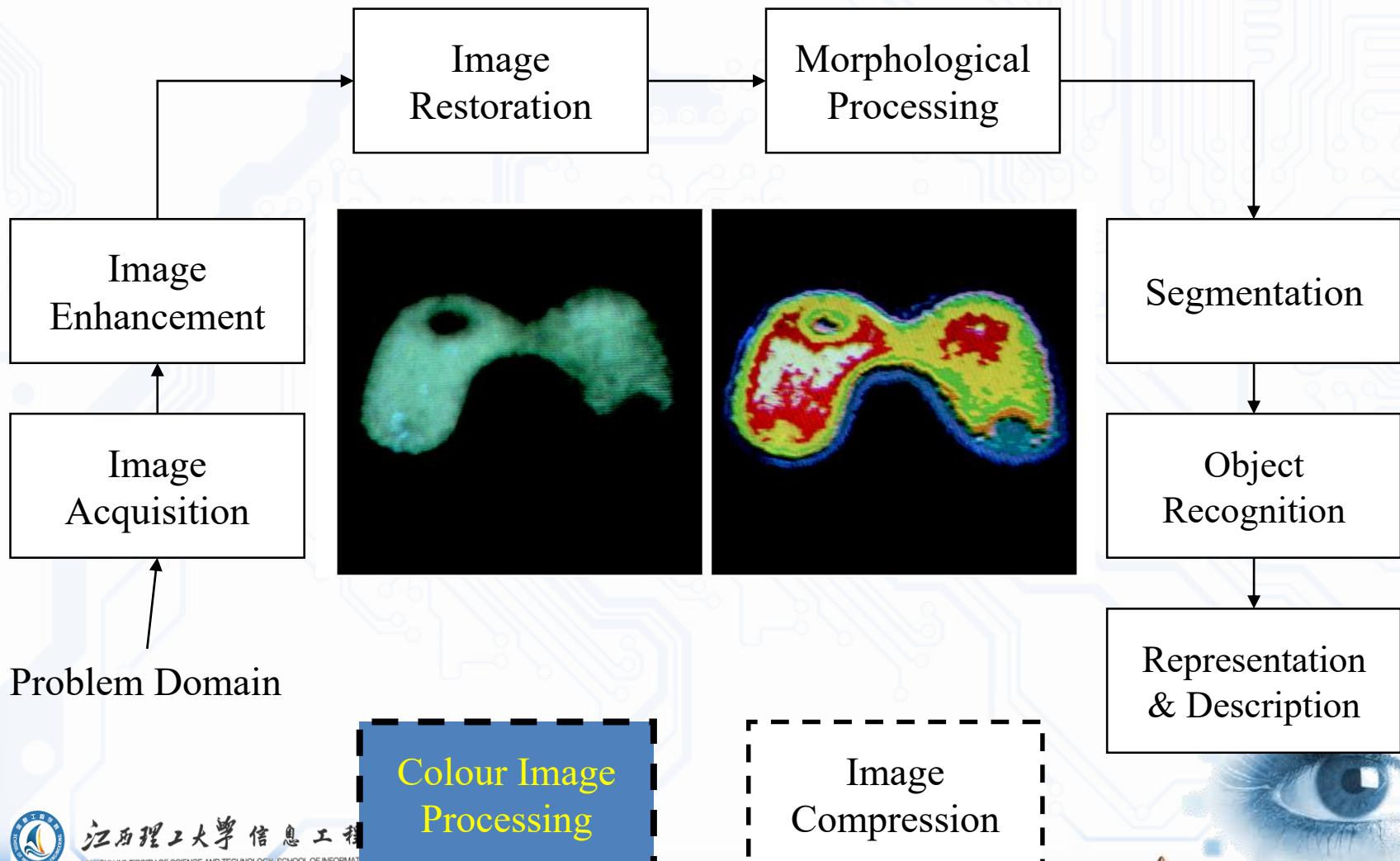
Outputs of these steps are generally images

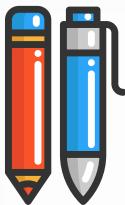


**Figure 1**



# Key Stages in Digital Image Processing: Colour Image Processing





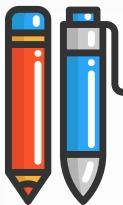
# 4. Color Image Processing

彩色图像处理  
Cāisè túxiàng chǔlǐ



- Color image processing is an area that has been gaining its importance because of the significant increase in the use of digital images over the Internet. This may include color modelling and processing in a digital domain etc.





# 5. Multi-Resolution Processing



多分辨率处理  
Duō fēnbiàn lǜ chǔlǐ

- It is the process of representing images in various **degrees of resolution**.



Average filter

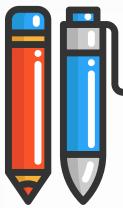


Median filter



Gaussian filter





## 6. Wavelets and Multiresolution Processing

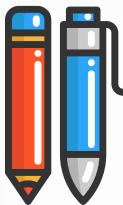
小波和多分辨率处理

Xiǎobō hé duō fēnbiàn lù chǔlǐ

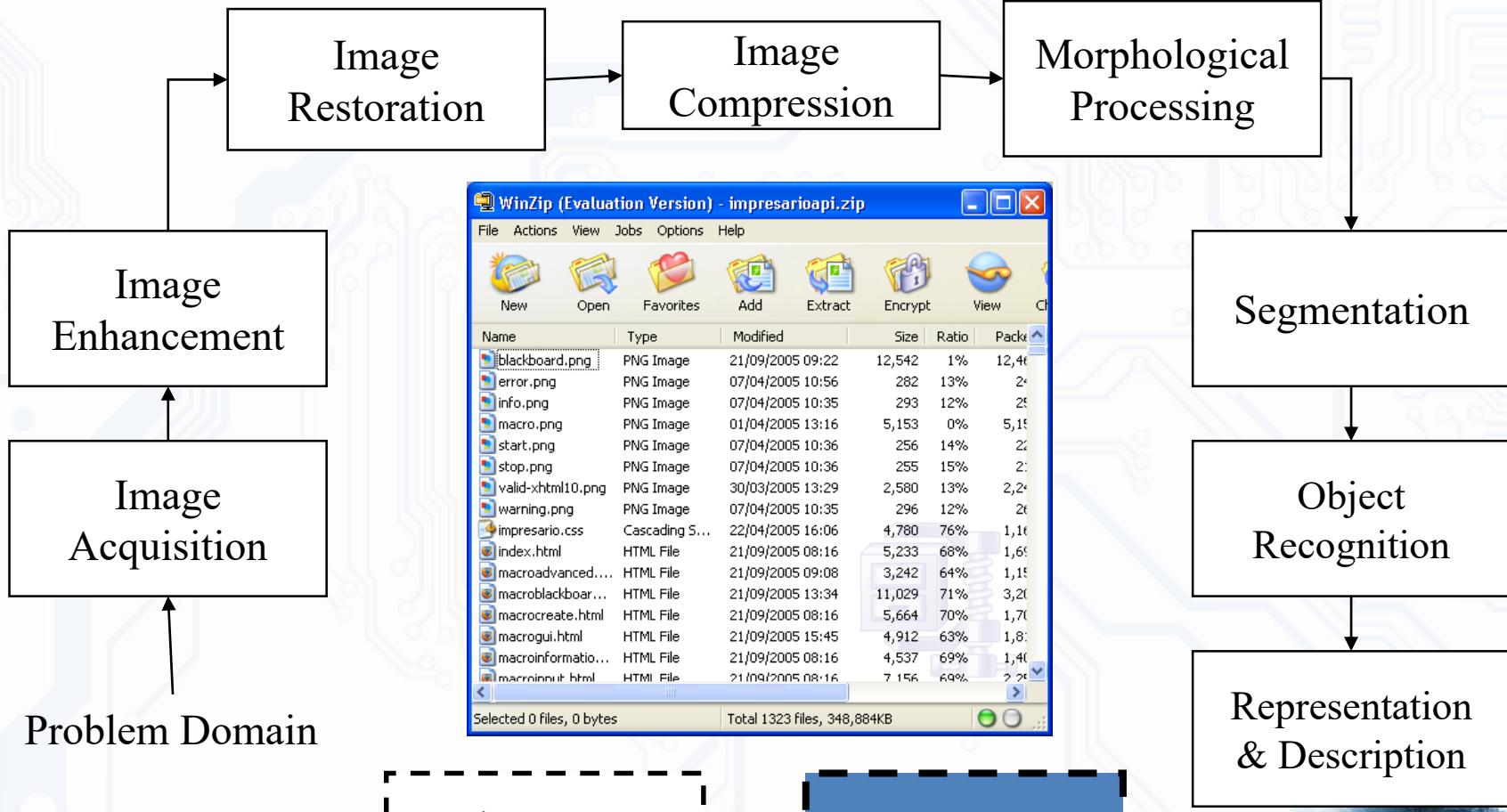


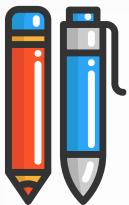
- Wavelets are the foundation for representing images in various degrees of resolution. Images subdivision successively into smaller regions for data compression and for pyramidal representation.





# Key Stages in Digital Image Processing:





# Image Compression

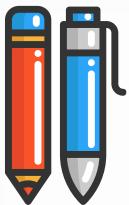


图像压缩 Túxiàng yāsuō

- Compression deals with techniques for reducing the storage required to save an image or the bandwidth to transmit it. Particularly in the uses of internet it is very much necessary to compress data.

减少存储的技术 Jiǎnshǎo cúnchú de jìshù





# Compression

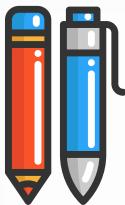


- It involves the techniques for **reducing the size** of the image with **minimum deterioration** in its **quality**.

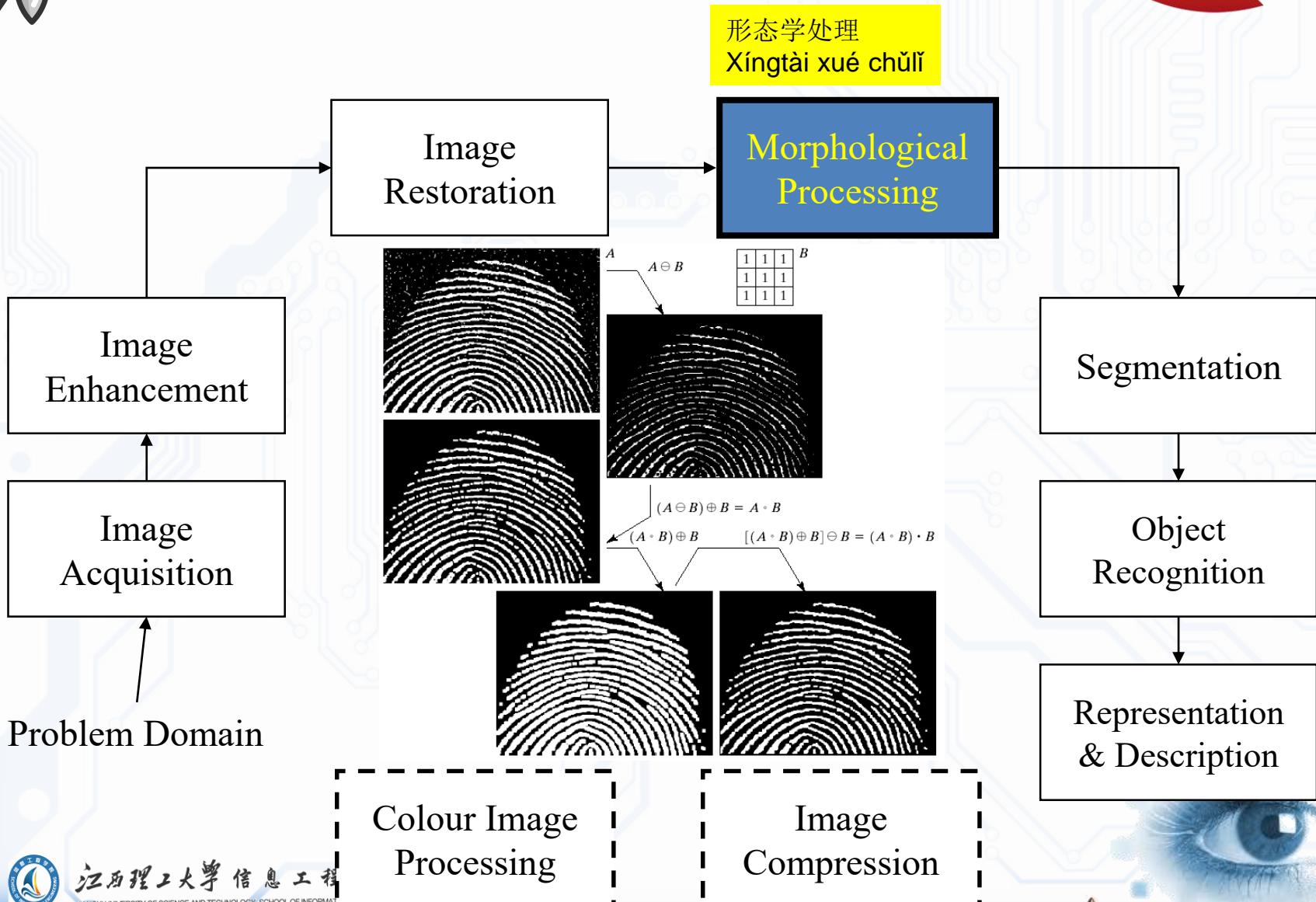


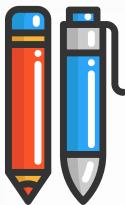
它涉及在图像质量下降最小的情况下减小图像尺寸的技术。

Tā shèjí zài túxiàng zhìlìàng xiàjiàng zuìxiǎo de qíngkuàng xià jiǎn xiǎo túxiàng chǐcùn de jìshù.



# Key Stages in Digital Image Processing:





# 7. Morphological Processing

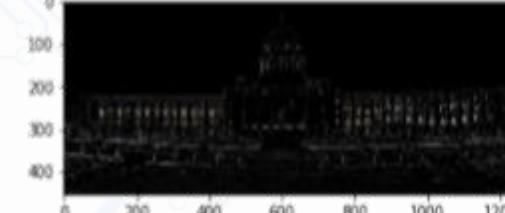
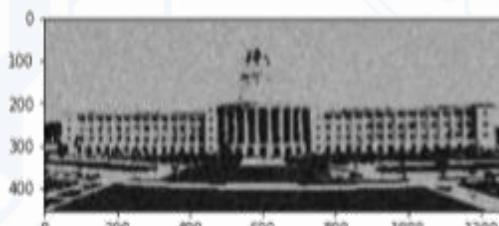
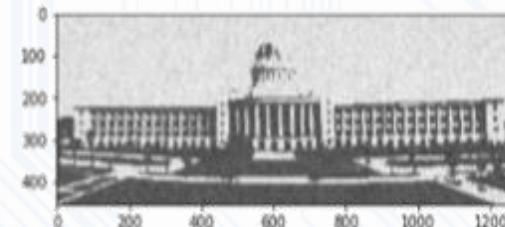
形态学处理

Xíngtài xué chǔlǐ



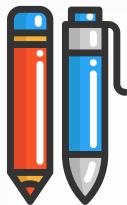
- Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.
- It is the process for **extracting** image components that are useful in the **representation** and **description** of shape.

提取图像成分的工具  
Tíqǔ túxiàng chéngfèn de gōngjù

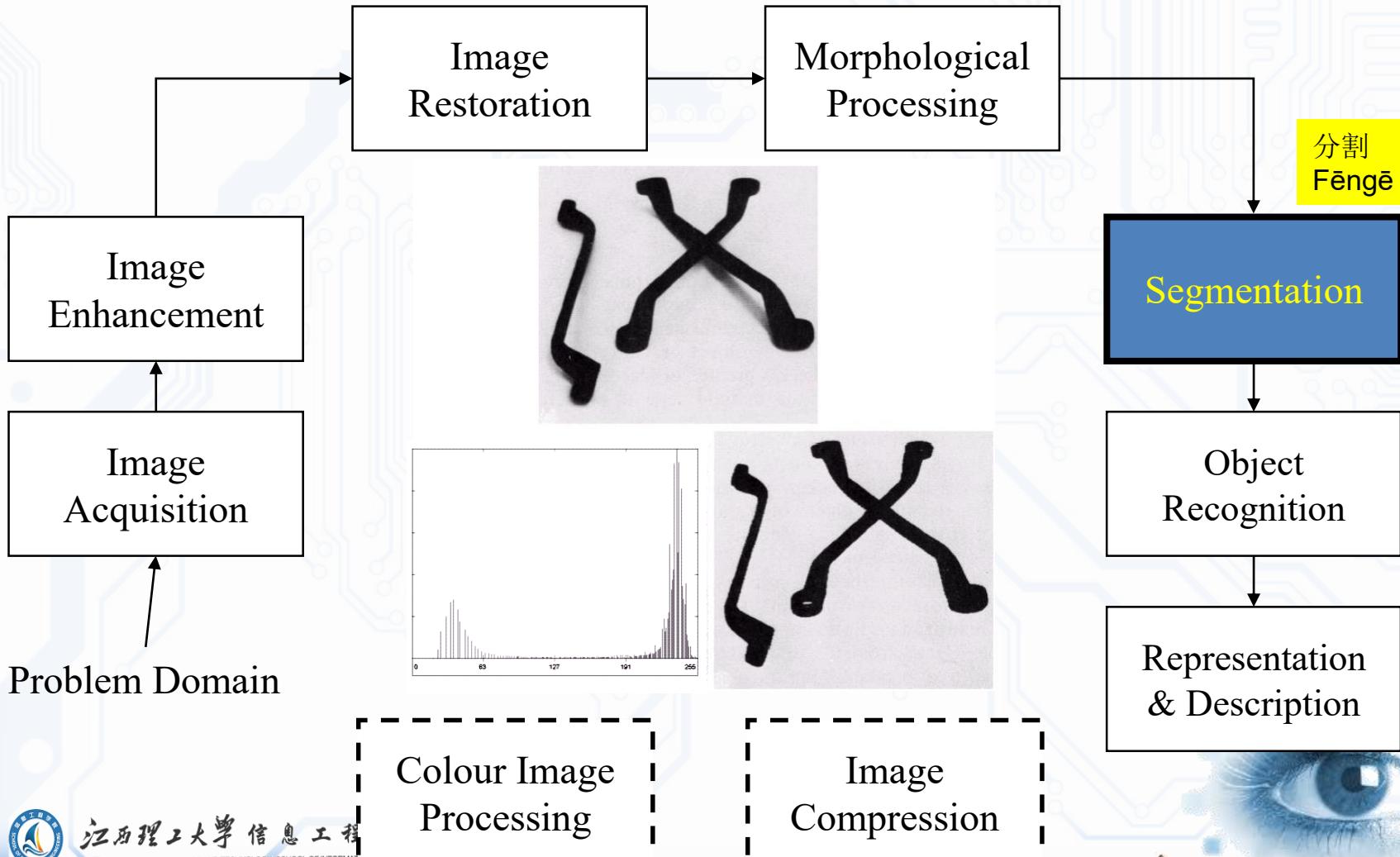


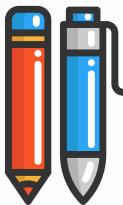
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JIANGXI UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF INFORMATION ENGINEERING





# Key Stages in Digital Image Processing: Segmentation





# 8. Segmentation

分割  
Fēngē

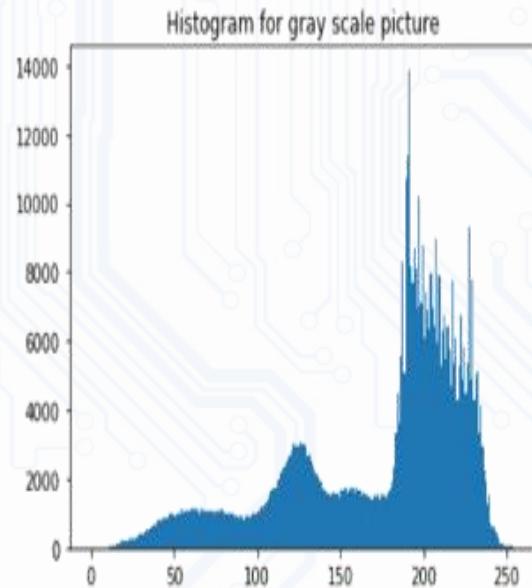
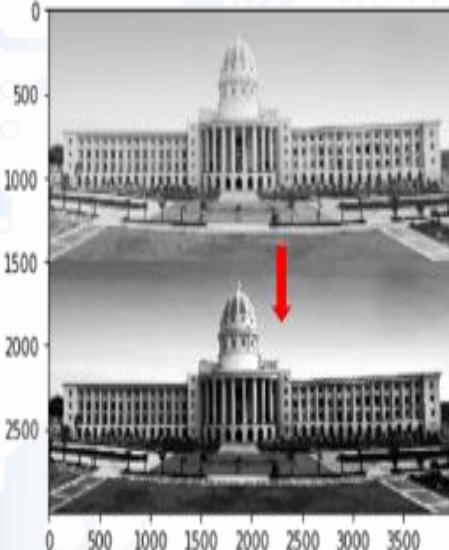


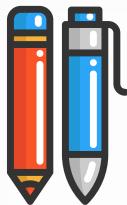
- Segmentation procedures partition an image into its constituent parts or objects. In general, autonomous segmentation is one of the most difficult tasks in digital image processing. A rugged segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually.

• It is the process of partitioning the image into **multiple segments**.

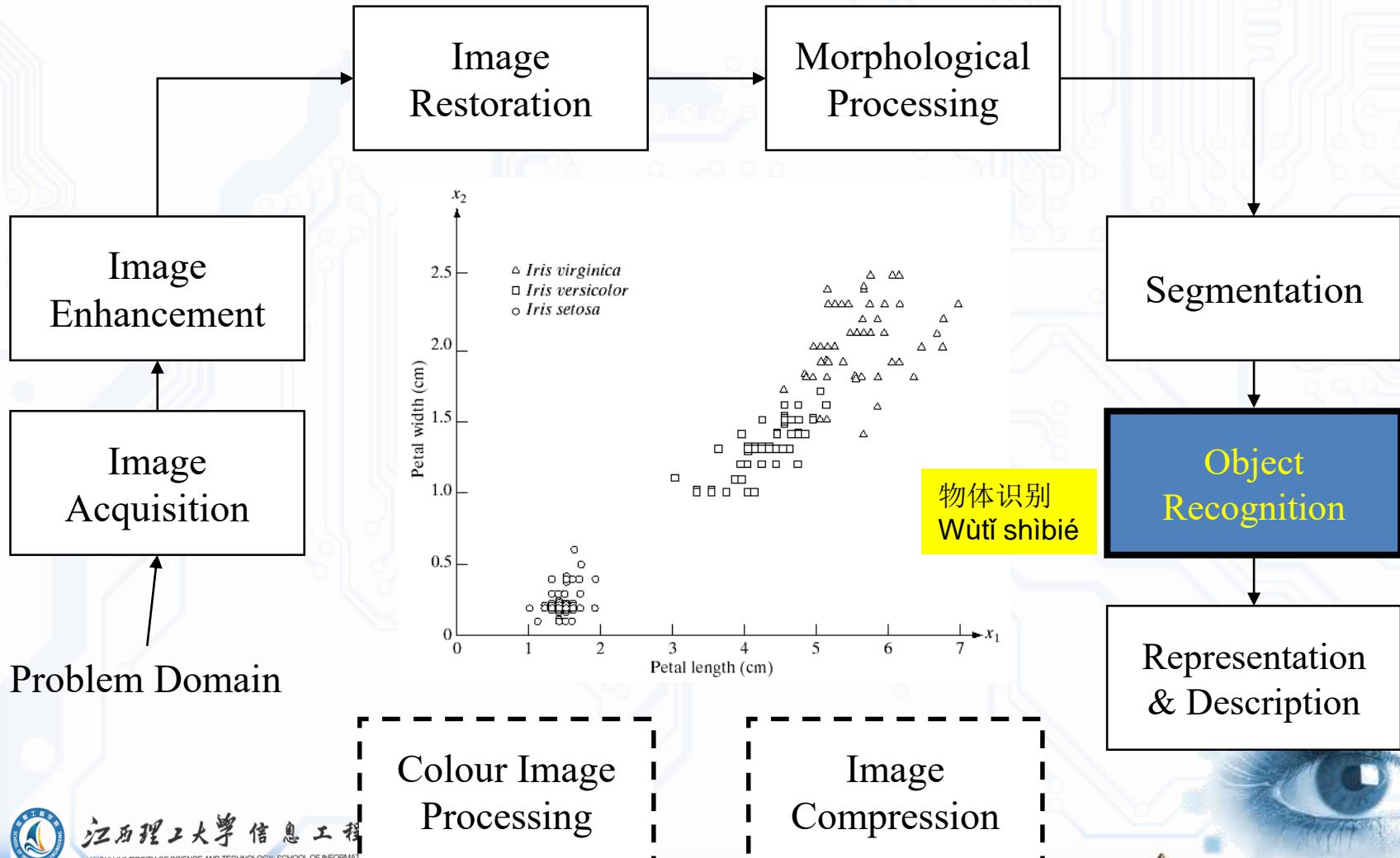
• 它是将图像分割成多个片段的过程。

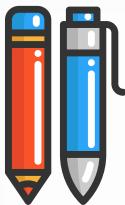
• Tā shì jiāng túxiàng fēngē chéng duō gè piànduàn de guòchéng.





# Key Stages in Digital Image Processing: Object Recognition



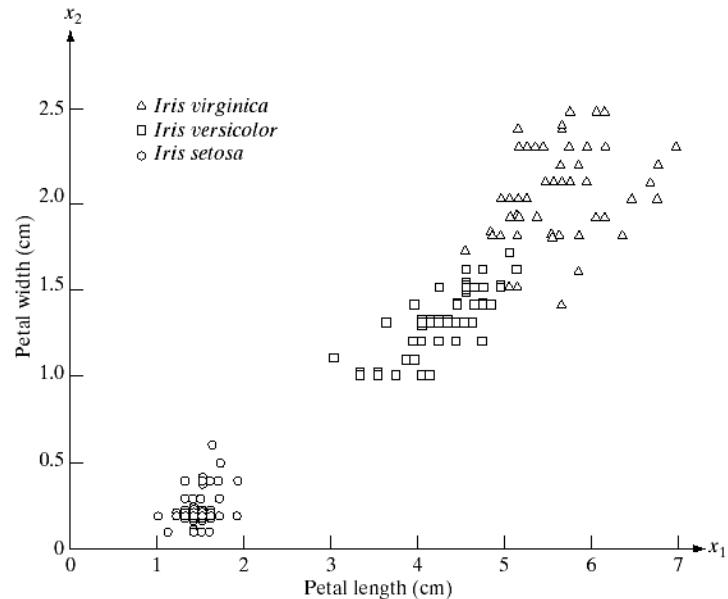


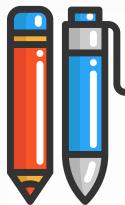
# 9. Object recognition



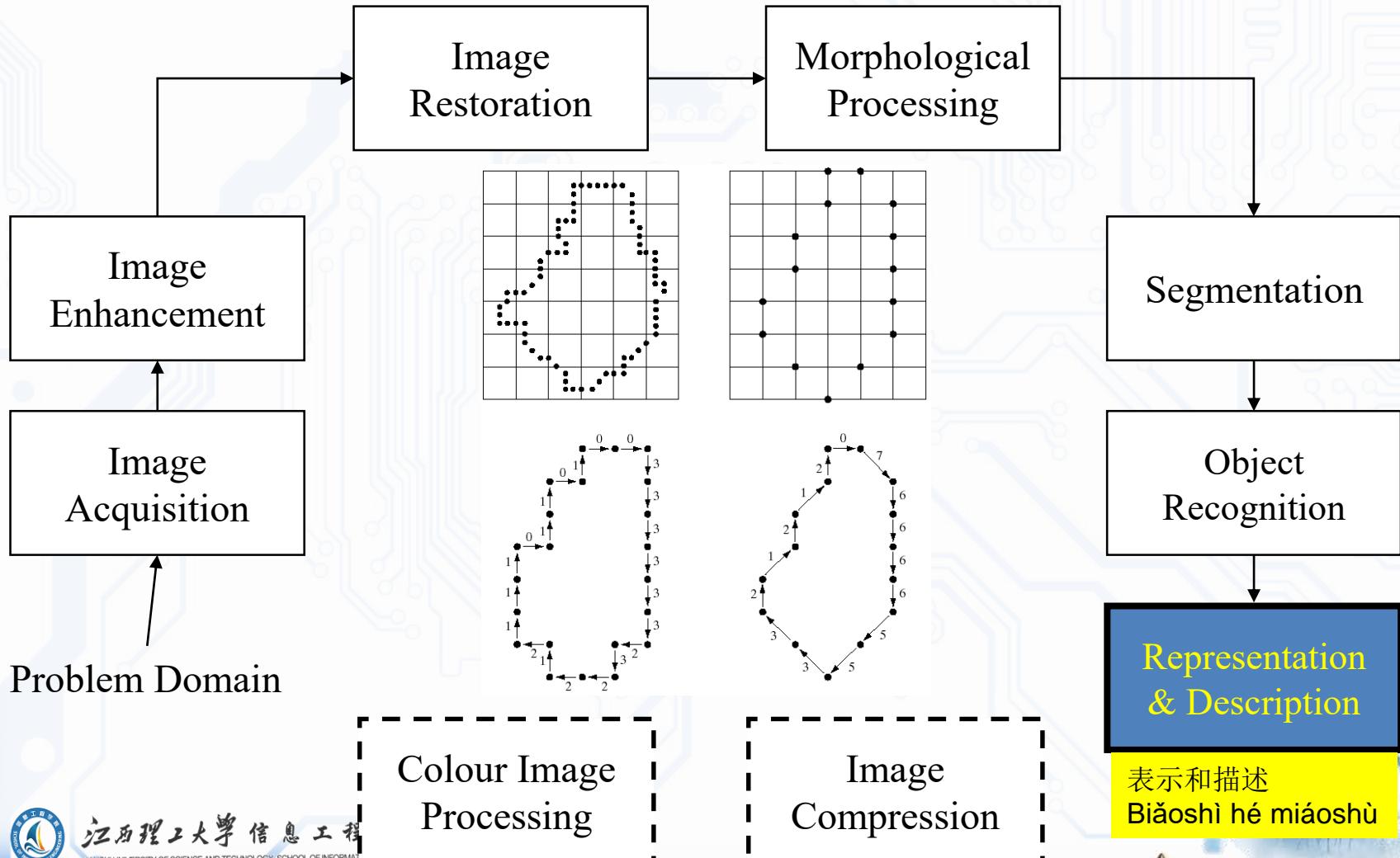
物体识别  
Wùtǐ shíbié

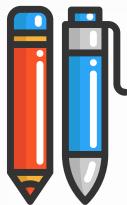
- Recognition is the process that assigns a label, such as, “vehicle” to an object based on its descriptors.





# Key Stages in Digital Image Processing: Representation & Description





# 10. Representation and Description

表示和描述  
Biǎoshì hé miáoshù



- Representation and description almost always follow the output of a segmentation stage, which usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself. Choosing a representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing. Description deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another.

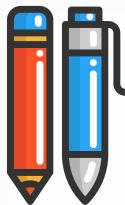
- It involves representing an image in various forms:
- **Boundary Representation** — It focuses on the **external shape** characteristics such as corners and inflections.
- **Regional Representation** — It focuses on **internal properties** such as texture and skeletal shape.

它涉及以各种形式表示图像：

边界表示——它侧重于外部形状特征如拐角和拐点。

区域表示——它侧重于内部属性，如纹理和骨架形状。



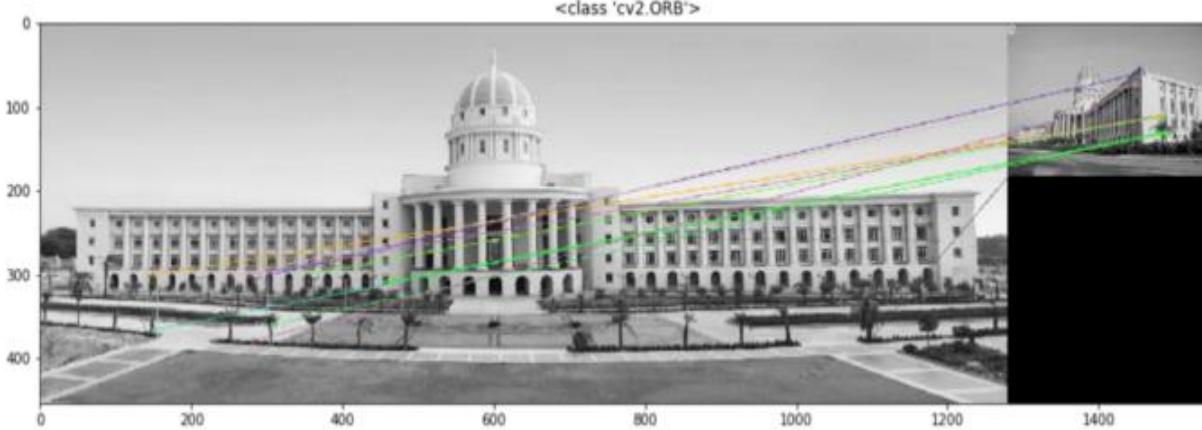


# Feature Matching

特征匹配  
Tèzhēng pǐpèi

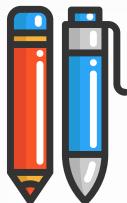


- We can extract the **same features** from a different image of the same cathedral taken from a **different angle**.



从不同角度拍摄的同一大教堂的不同图像中的相同特征  
Cóng bùtóng jiǎodù pāishè de tóngyī dà jiàotáng de bùtóng túxiàng zhōng de xiāngtóng tèzhēng





# Recognition

认出  
Rèn chū



- It is the process of **assigning labels** to an object based on its **description**.



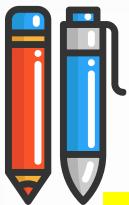
根据对象的描述为对象分配标签

Gēnjù duìxiàng de miáoshù wèi duìxiàng fēnpèi biāoqīān



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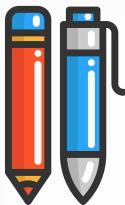


# 11. Knowledge Base:



知识库: Zhīshì kù:

- Knowledge may be as simple as detailing regions of an image where the information of interest is known to be located, thus limiting the search that has to be conducted in seeking that information. The knowledge base also can be quite complex, such as an interrelated list of all major possible defects in a materials inspection problem or an image database containing high-resolution satellite images of a region in connection with change-detection applications.
-



# Summary\_ Fundamental Steps in DIP



Extracting image components

Outputs of these processes generally are images

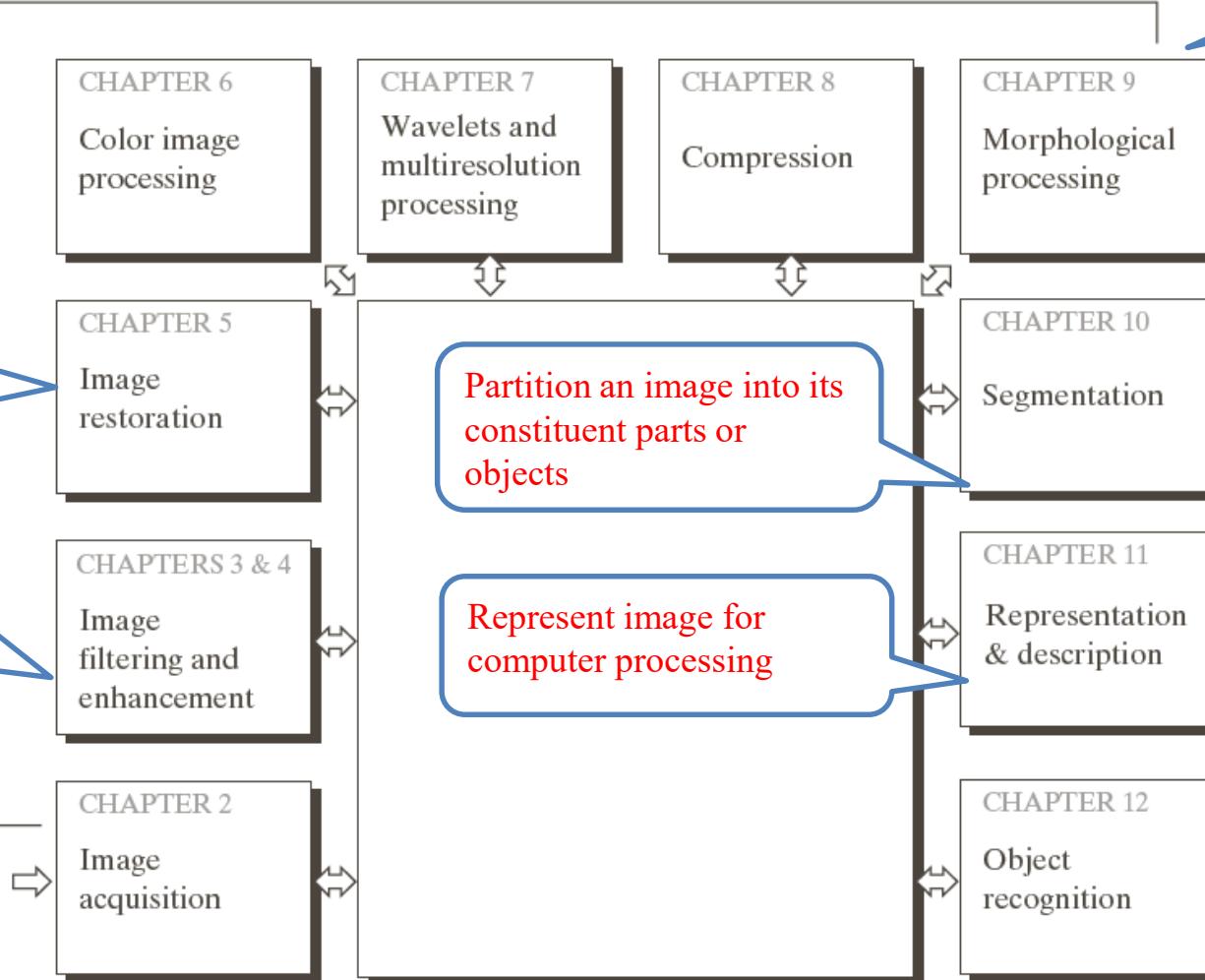
改善外观  
Gǎishàn wàiguān

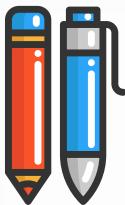
Improving the appearance

Result is more suitable than the original

结果比原来更合适  
Jiéguǒ bǐ yuánlái gèng héshì

Problem domain



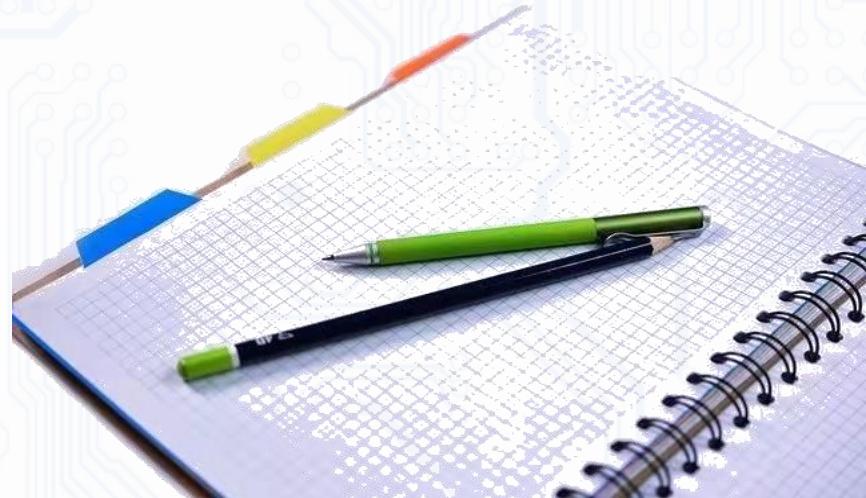


# Student Task\_1: DIP



- Find the name of famous algorithm in digital image processing and compare them in the table form

**Send for Next lecture**



- Send on MOOC system



“Reading allows  
you to travel, to  
make other  
people’s  
experiences your  
own.”

MARIO VARGAS LLOSA  
Nobel Prize in Literature 2010

江西理工大学

Jiangxi University of Science and Technology

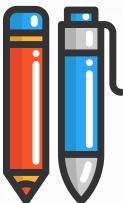
信息工程学院

School of information engineering

## Digital Image Processing

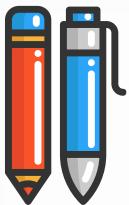
THANK YOU





**“BE HUMBLE. BE HUNGRY.  
AND ALWAYS BE THE  
HARDEST WORKER  
IN THE ROOM.”**





# Reference



- **Images taken from Gonzalez & Woods, Digital Image Processing (2002)**
- **Wilhelm Burger and Mark J. Burge, Digital Image Processing, Springer, 2008**
- **University of Utah, CS 4640: Image Processing Basics, Spring 2012**
- **Gonzales and Woods, Digital Image Processing (3<sup>rd</sup> edition), Prentice Hall**
- **Digital Image Processing slides by Brian Mac Namee**
- **Fundamental Steps of Digital Image Processing, Ananta Arora, Aug 7, 2019 • 4 min read**
- **Ages Taken From Gonzalez & Woods, Digital Image Processing (2002)**

