

数字图像处理

Digital Image Processing

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Notice

■ Text book & References

R. Gonzalez and R. Woods的 Digital Image Processing, 第3版（英文版）Prentice Hall, ISBN 9780131687288, Published by “电子工业出版社” .

No Chinese translation version allowed in this course.

■ Related web-site: some homework solutions, projects and tutorials.

http://www.imageprocessingplace.com/root_files_V3/students/students.htm

■ BBS

http://www.imageprocessingplace.com/root_files_V3/Forum_link_pages/forum.htm

Notice

- ❖ 主要内容: 第1~6章, 第8章简介, 9~10章介绍主要思想, 以动手为主
- ❖ 背景(先导)知识: 简单的概率统计、富里叶变换(**Fourier Transform**)、数据结构与算法设计、使用**Matlab**数值计算软件
- ❖ 要求:了解图像处理的基本知识和基本问题的求解途径
- ❖ 辅助工具: **PhotoShop (or ACDsee)**看图软件、**Matlab**软件
- ❖ 学习方式: *Learning by doing*
- ❖ 考试方式: 基本概念 + 课题报告+平时作业
- ❖ 教学计划: 《数字图像处理》课程教学大纲.pdf
- ❖ 各种通知 (包括作业) :见课程网站

<http://gitl.sysu.edu.cn/dip/>

课程主页：<http://gitl.sysu.edu.cn/dip/>

教师主页：<http://ss.sysu.edu.cn/~chhy>

微博：<http://weibo.com/1794892070>

4个博士生TA：郭俊、杨晓宇、张弛、王婷婷

个人基本情况

- ▶ 理学博士（计算数学，**1988**）、教授、博导、**2004**年中山大学百人计划引进人才回国任教
- ▶ 中大软件学院主要创建人
- ▶ 美国斯坦福访问学者（**1994**）、美国北德州大学访问教授（**1995-1998**）
- ▶ 在美国工作近十年，其中包括在美国软件公司工作八年
- ▶ 设计的视频图像产品被跨国大公司签约使用
- ▶ 拥有**3项美国专利和4项中国专利（授权）**
- ▶ **40篇以上专业论文**，包括顶级学术会议和学术期刊（如**TCSVT、TMM、ECCV、SIGGIS等**）；承担国家级、省部级等多项科技项目
- ▶ **2000**年作为主编和作者出版了一本散文集《三色土》

在美国设计的产品（1995-2003）

Enabling the Visual Environment



在美国设计的产品清单

- LSVX – Lightning Strike



ORACLE®

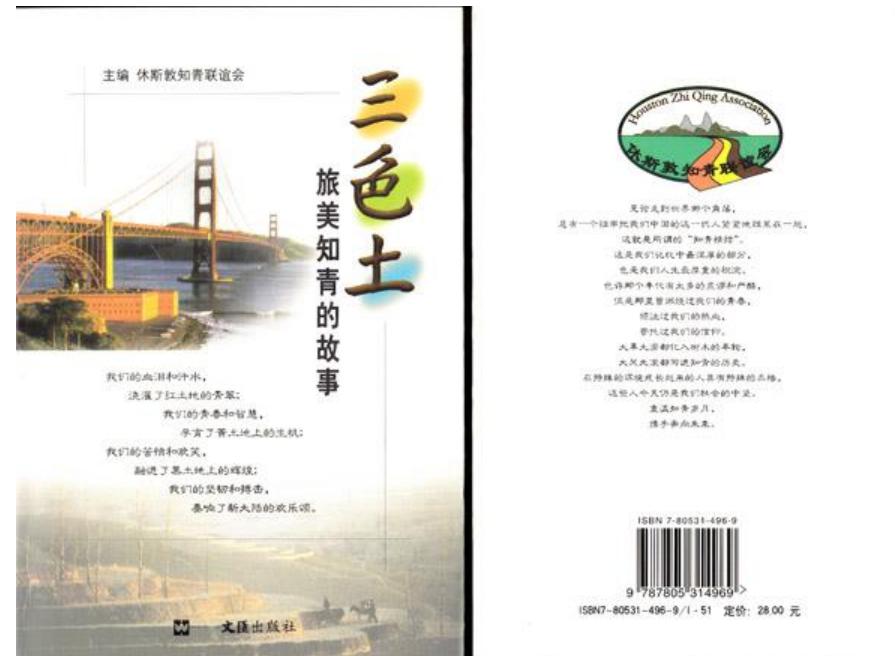
The logo is the word "ORACLE" in red capital letters with a registered trademark symbol.

NOKIA
Connecting People

The logo consists of the word "NOKIA" in blue capital letters with "Connecting People" in a smaller blue font below it.

Bai du 百度

The logo features the Chinese characters "百度" next to the English word "Baidu" in blue, with a blue paw print icon integrated into the letter "d".



打败天才“老毛子”——《世界之窗》2001年第9期，
《青年文摘》2001年第12期

登高而招，臂非加长也，而见者远；顺风而呼，声非加疾也，而闻者彰。假舆马者，非利足也，而致千里；假舟楫者，非能水也，而绝江河。

——荀子劝学

图画作为人类最早期的叙事方式，在人类文明出现以前，就成为史前文明时代最重要的交流方式。几千年之后的今天，“读图时代”再次到来。

2011年，百度CEO李彦宏曾预测，图片将是中国互联网未来的三大机遇之一。“未来的两三年之内，可能会在图片领域涌现出一批不错的公司”。

预言现在已变成了现实，无论是Instagram、Pinterest、Path、Camera+，还是国内的美图秀秀、美丽说、花瓣.....

“图片”都成为了其中的最重要因素之一。



图画作为人类最早期的叙事方式，在人类文明出现以前，就成为史前文明时代最重要的交流方式。

几千年之后的今天，“读图时代”再次到来。

两者有什么不同？

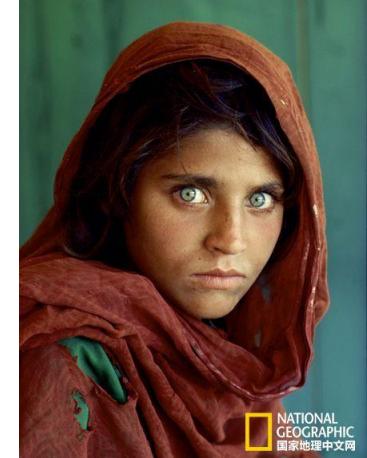
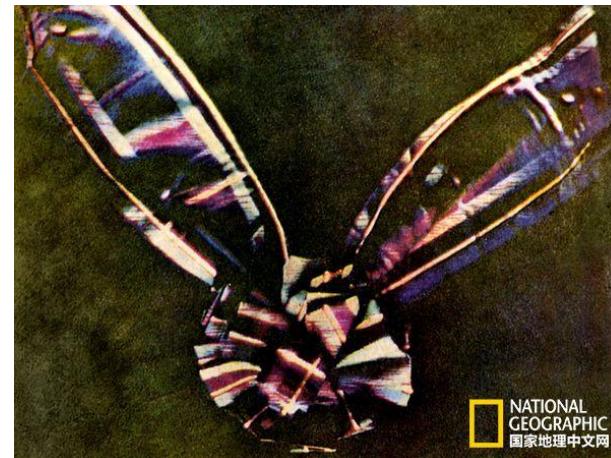


xh.5156edu.com



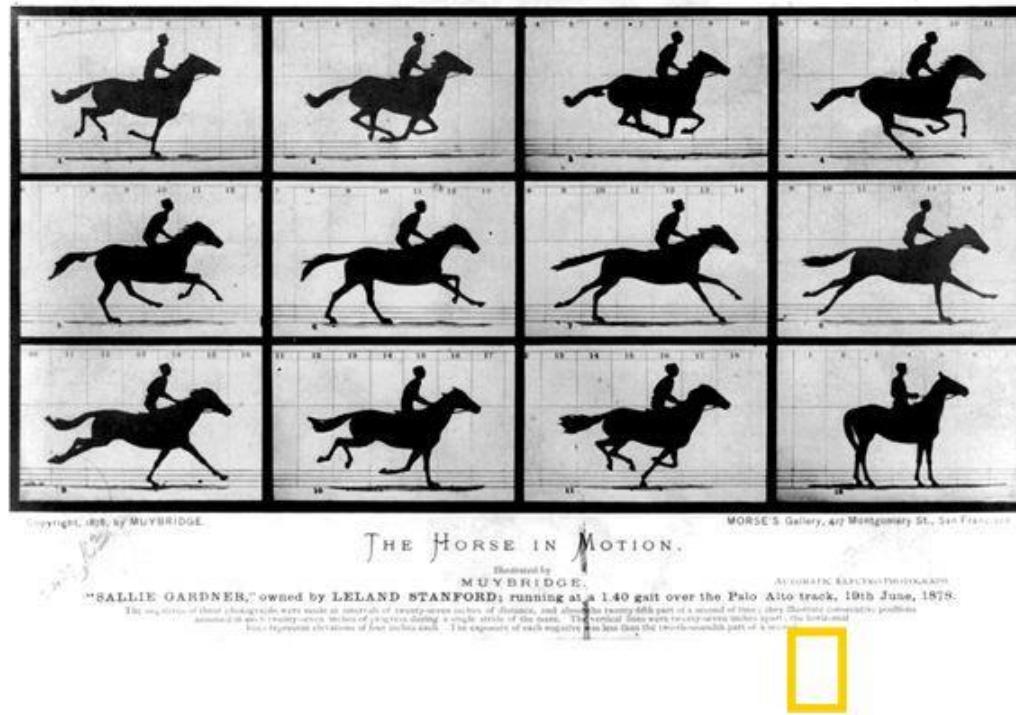
From the world first picture to Kodak announced the cessation of film production, image science and social science has been a complementary to each other, common development and evolution.

Anonymous



摄影里程碑: ——国家地理中文网

从世界第一张照片到柯达公司宣布停止胶卷生产，图像科学和社会科学一直相互影响，共同发展和演化。



国家地理中文网：第一张拍摄运动场景的照片，摄影：Eadweard Muybridge, 1878

One picture is worth more than ten thousand words.

Anonymous



One more picture



@西里村
weibo.com/u/1794892070

Thomas Moran(1837-1926)在1871年参加美国西部地理考察时记录考察活动并绘制了相关的图像。他的这幅油画推动了总统和国会在黄石建立国家公园的提案。他也因此成为了成功的艺术家并获得经济上的支持。之后他把自己的签名改为 [T-Y-M: Thomas "Yellowstone" Moran](#)

Another pictures



西里 2007年8月16日摄于奥林匹克国家公园

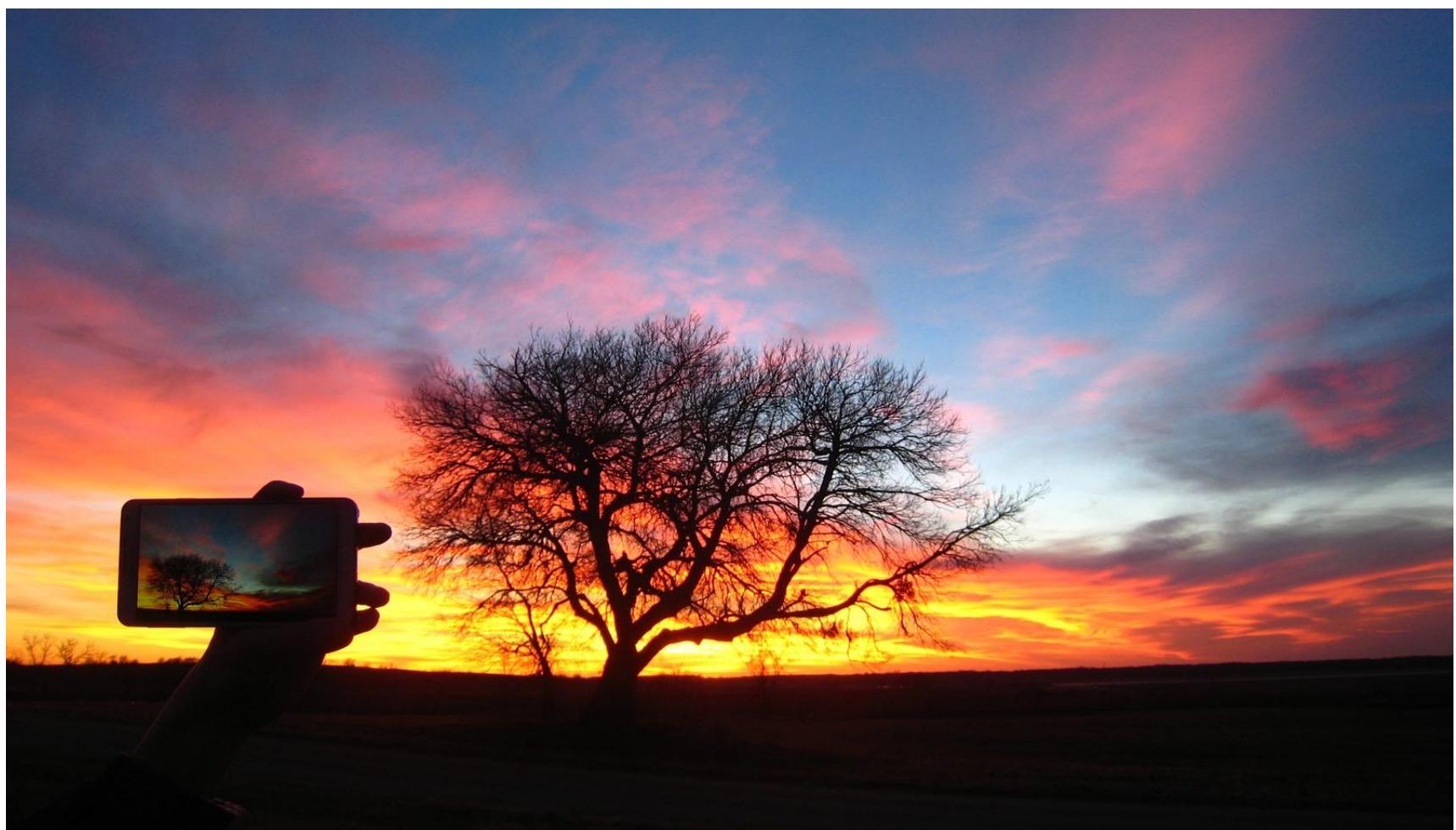
图像是阅尽天下美景的重要途径

Another pictures



图像是阅尽天下美景的重要途径

Another pictures



Another pictures



图像是分享天下美景的重要途径

Another pictures



图像是分享天下美景的重要途径

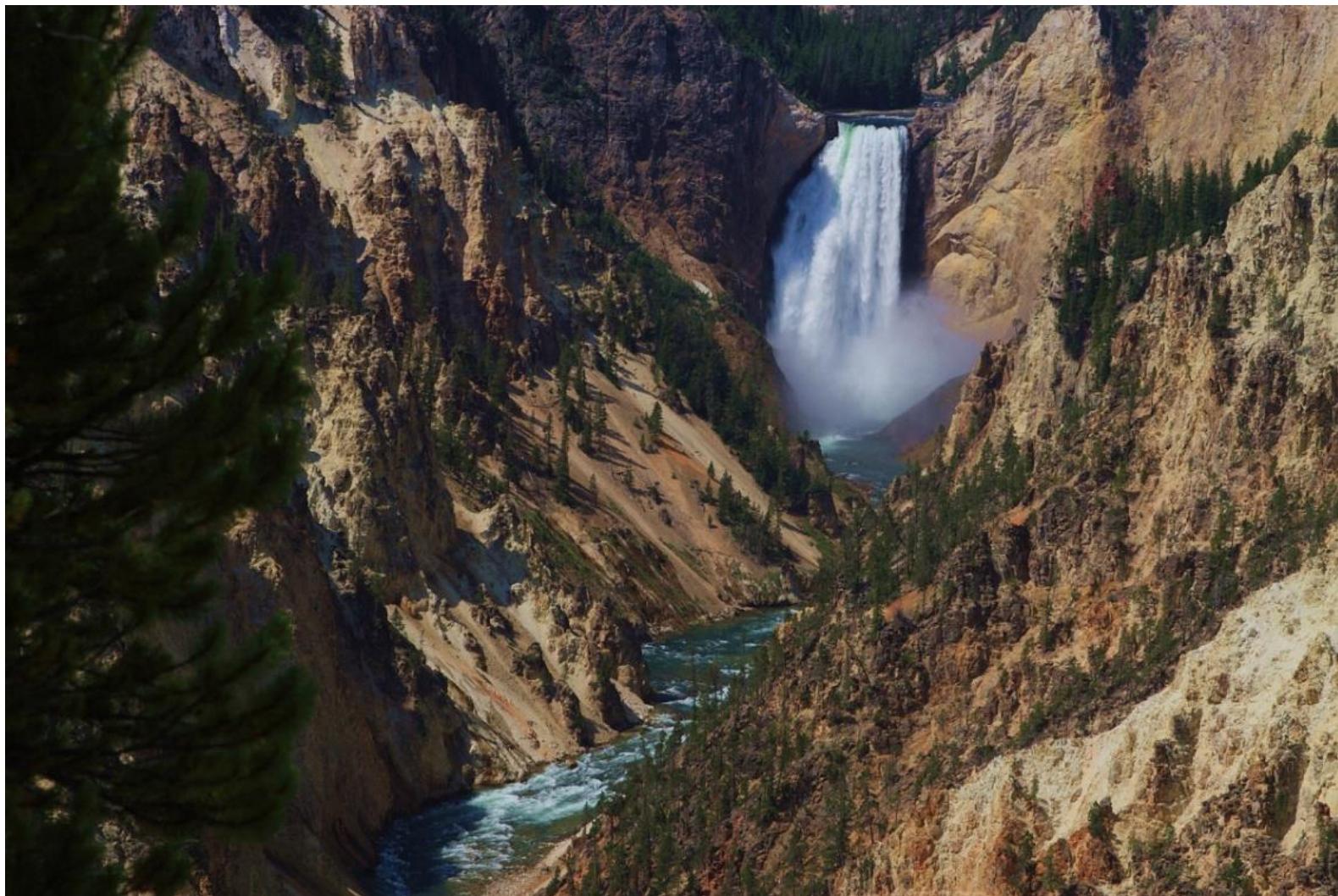
Yellowstone Park



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weibo.com/u/1794892070

http://en.wikipedia.org/wiki/Thomas_Moran#Yellowstone_images

Yellowstone Park



Yellowstone Park



Yellowstone Park



Yellowstone Park

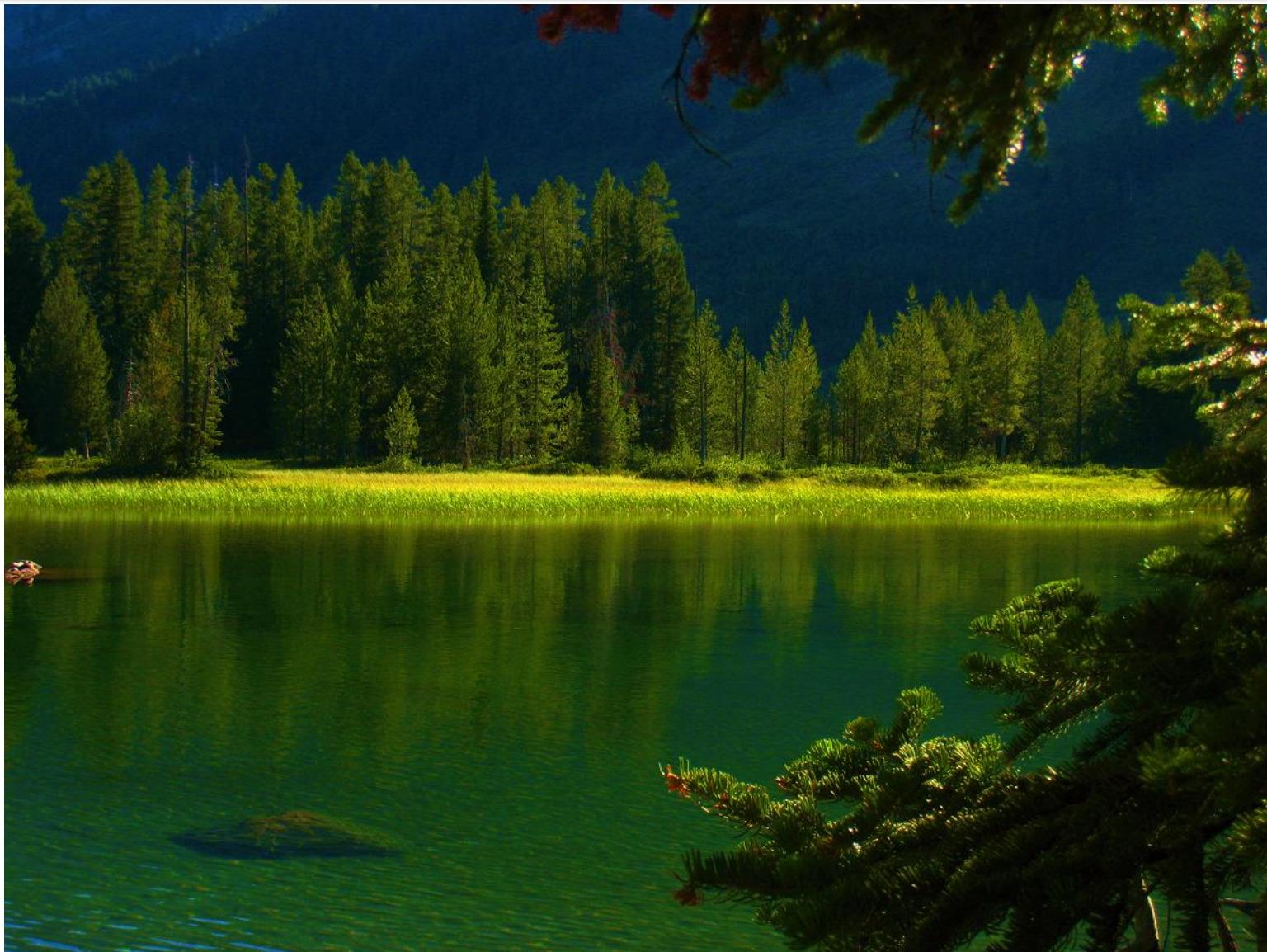


Yellowstone Park



位于黄石湖旁的West thumb 热泉盆地

Grand Teton Park



Question



How does digital camera work?

What is the meaning of image resolution?

What are the main factors of taking pictures?



✓ 希腊夜景









Question



How does digital camera work?

What is the meaning of image resolution?

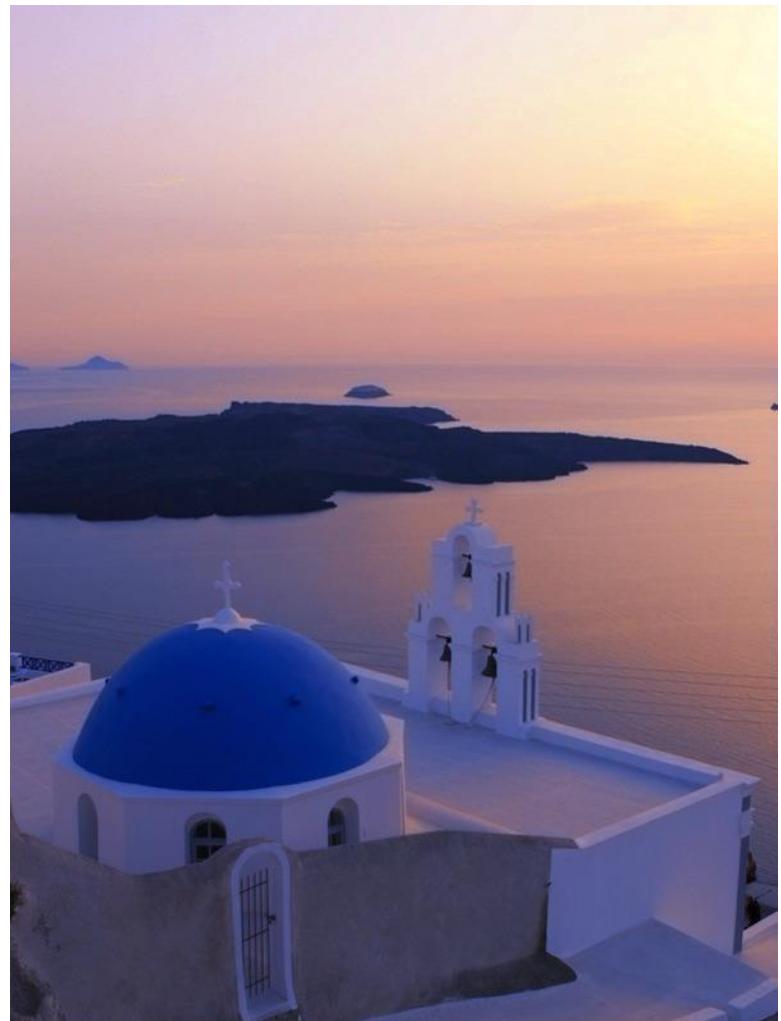
What are the main factors of taking pictures?

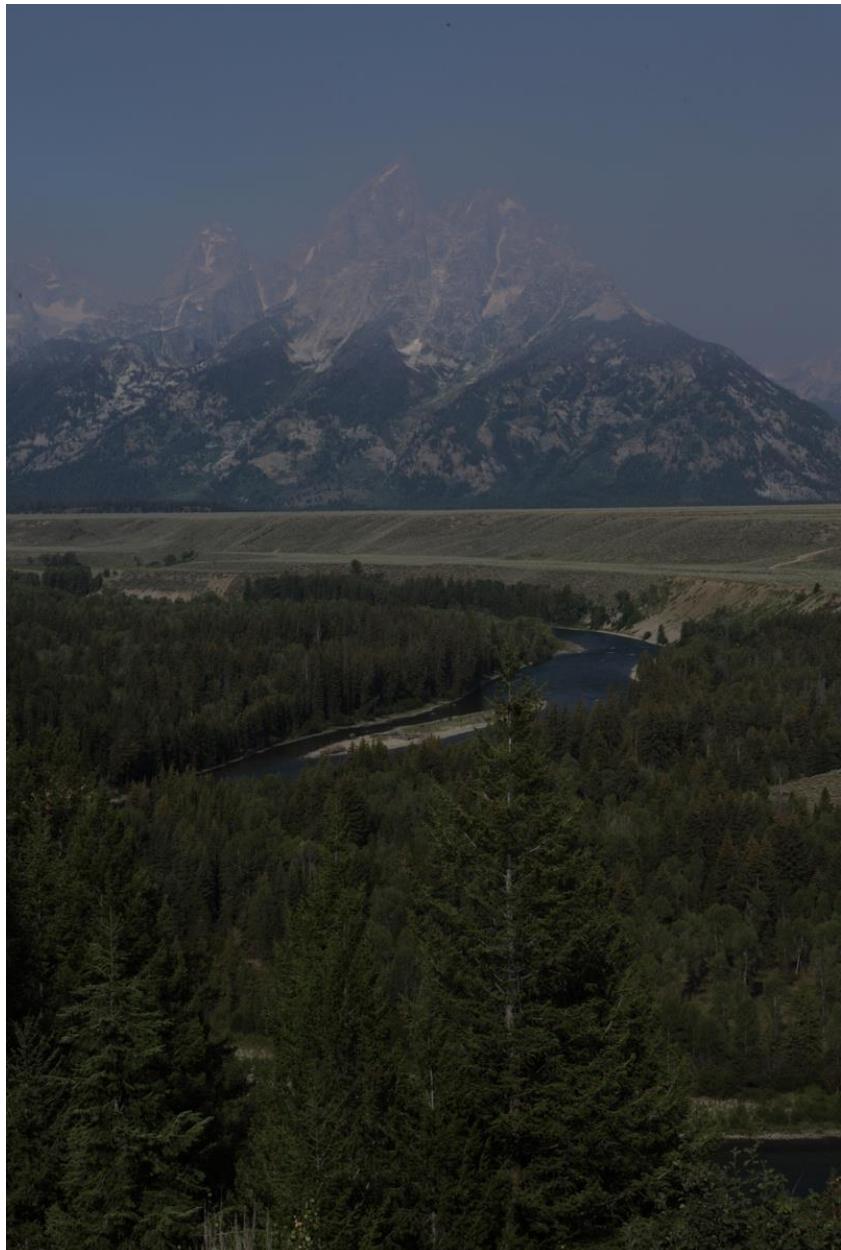
How do you take a “good” night scene picture ?

Another picture



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Question

How does digital camera work?

What is the meaning of image resolution?

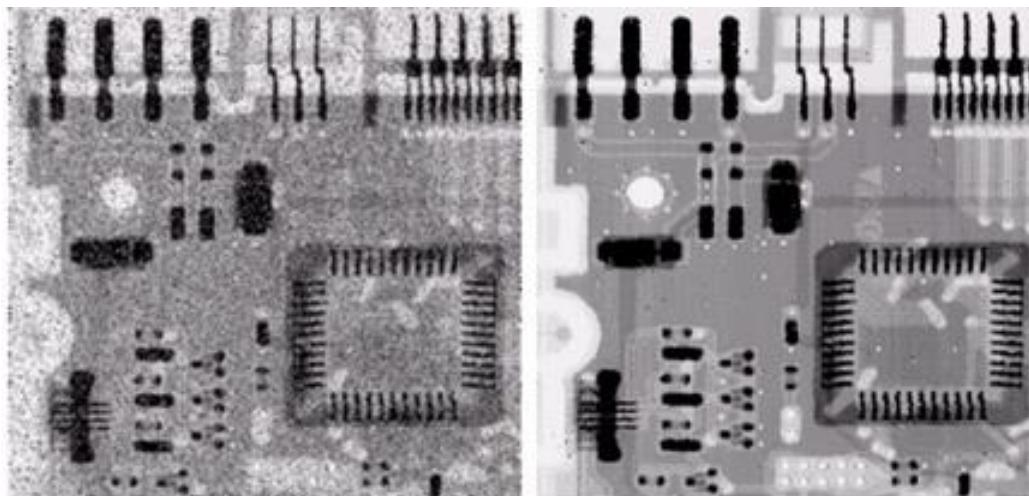
How do you take a clear night scene picture ?

What parts are related to DIP and how does it work ?



Applications of Image Processing

- ◆ Digital image processing discusses how to treat digital images by means of a digital computer for noise filtering, blurred image restoration, image compression, and image understanding and pattern recognition.



noise
filtering

Image enhancement

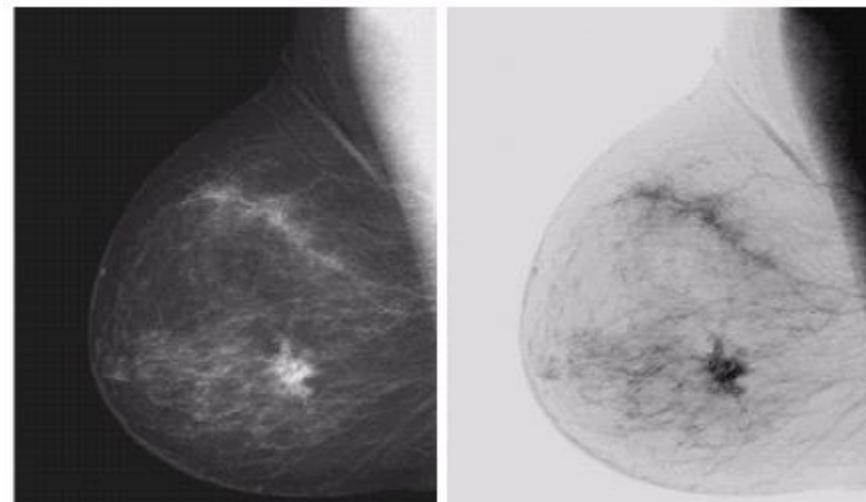


Image restoration

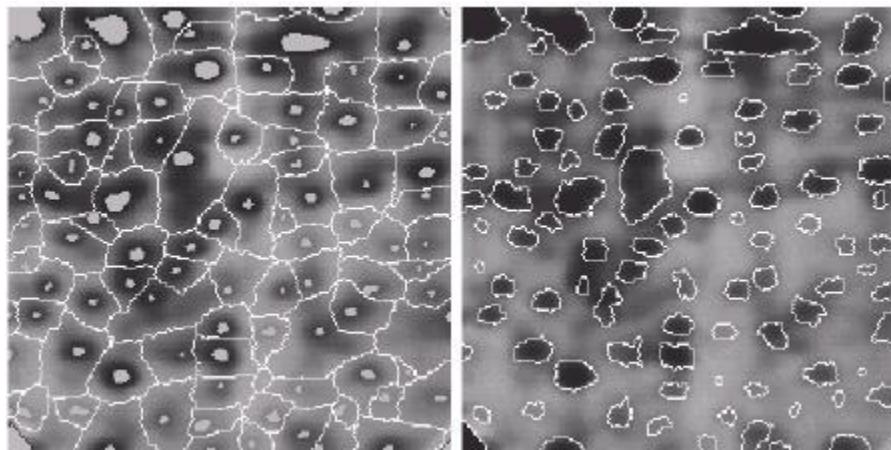


Image analysis: Segmentation

Image understanding: Finger print recognition



Some interesting topics in the area of digital image processing

1、高动态亮度范围图片内容的显示—High Dynamic Range Imaging

Low dynamic range images (24 bits/pixel) cannot capture the full dynamic range of the scene on a single image

在不同的亮度范围内得到不同的图像



高动态图像在不同曝光度下的显示效果对比



低曝光



中曝光



中高曝光



高曝光

经过使用某种图像处理技术，获得下述图像



用途: 改善数码相机在这种环境下的输出图像的质量? 现代数码相机已经具备在高动态范围(**High Dynamic Range**)成像的能力,但在转化为24位数码图像需要量化时,通常会出现类似前面的情况.

存在的问题:



PS处理的图像



我们的方法一



我们的方法一结果



我们的方法二结果

2、改善图像质量(Image Enhancement)

数码相机或者其他获得数字图像的设备因为种种原因,图像的质量强差人意,如何改善图像的质量?



经过处理图像
的外观质量得
到了改善.

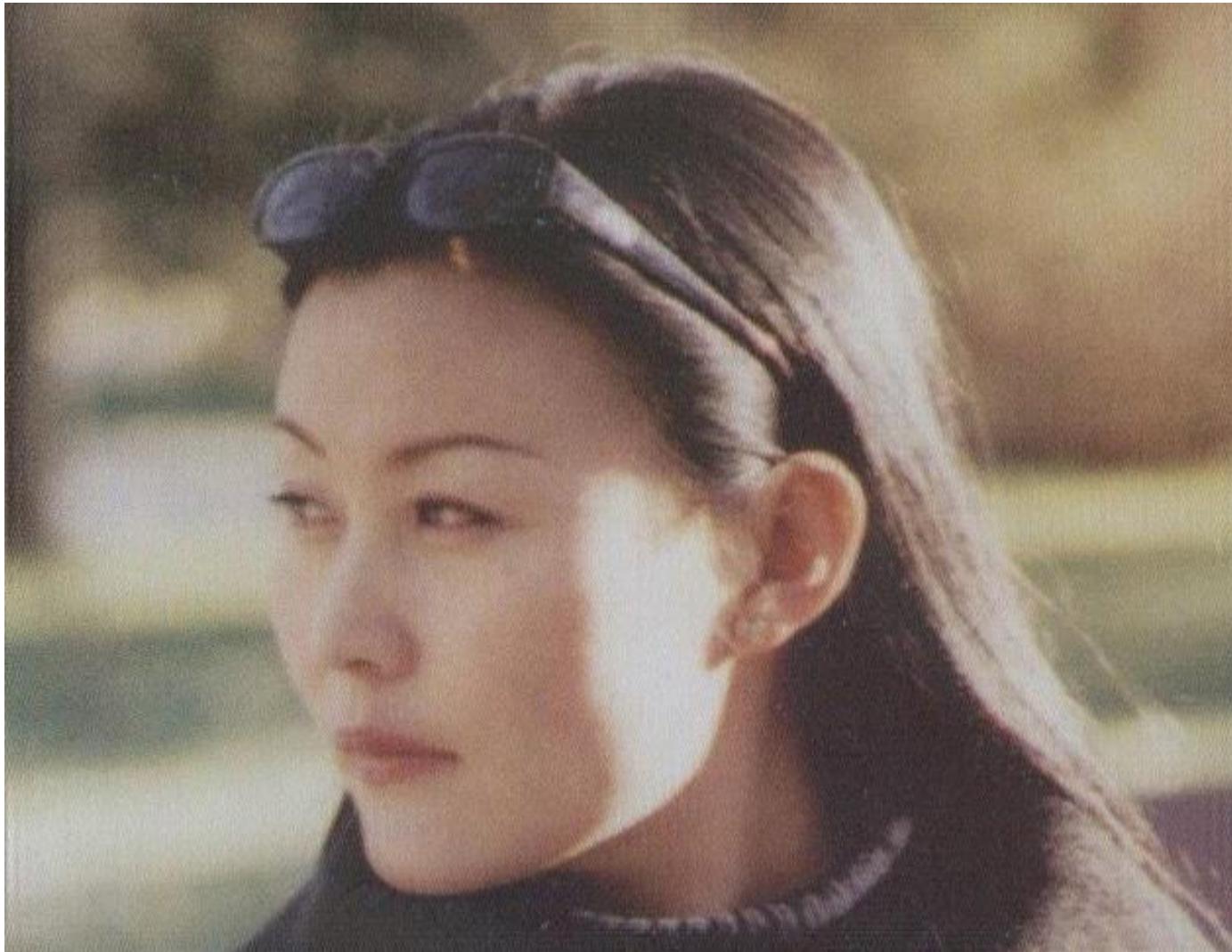
How & why?

扫描仪引出的附加噪声, 如何去除?

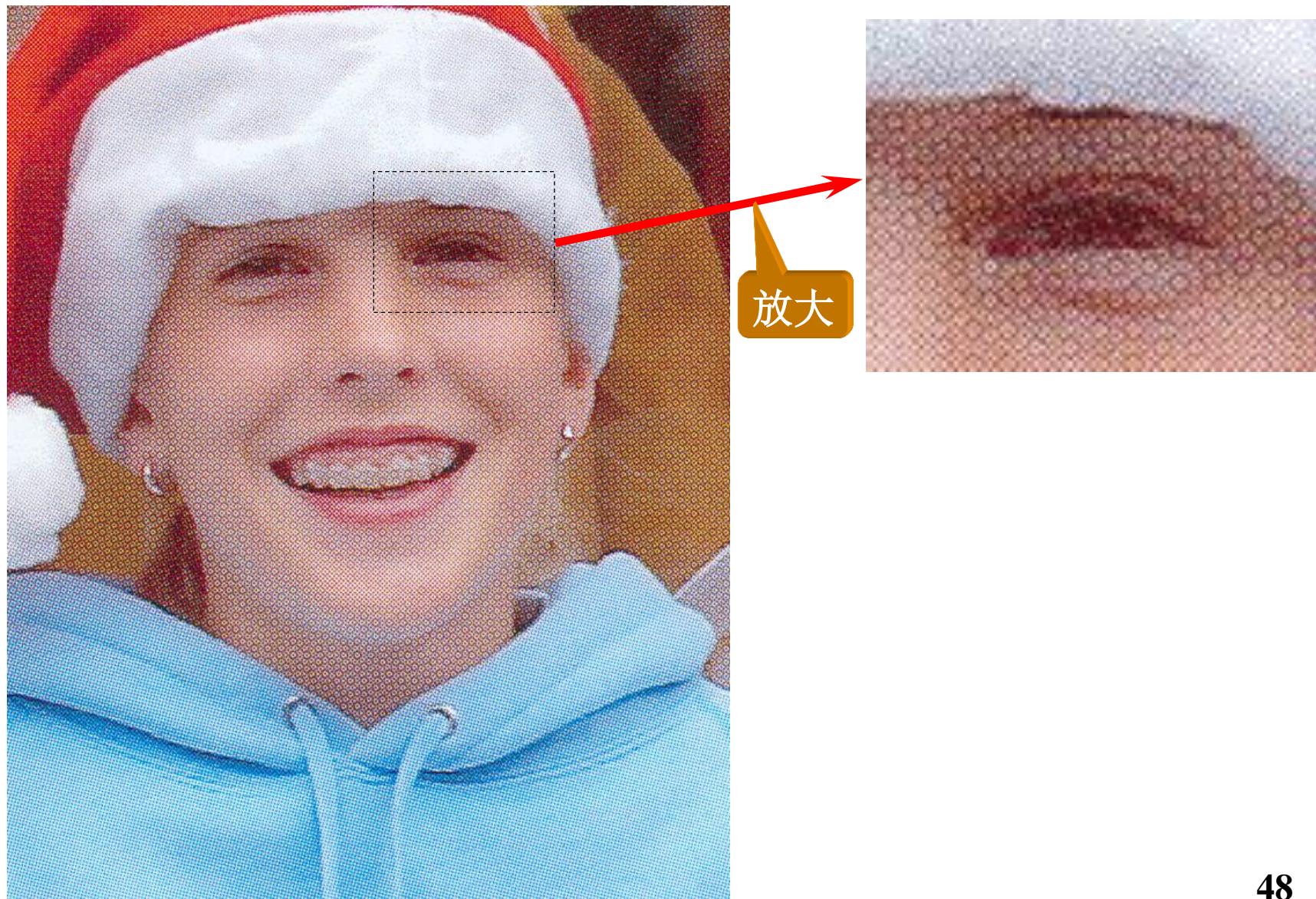
效果1

效果2

效果3



低分辨率半色调纸质印刷品在高分辨率扫描时会出现严重畸变, 如何消除?





3、地理、地貌信息、地图的存储、浏览:

例如: Google Earth 和微软的Virtual Earth, <http://local.live.com/>
Zoom in & Zoom out, 从一个局部到另一个局部、每个局部物体
的Zoom in/out、去阴影等.



如何构造一种合适的数据结构来存储这张图像使得能够？

For example, scene changes gradually from one to another during the chick walks



Need a lot of pictures between

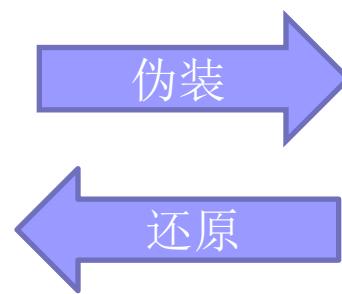


4、图像信息隐藏



晚上9点到荣光堂会面

5、信息加密和信息伪装





Data, Data, Everywhere

Data are becoming the new raw material of business : an economic input almost on a par capital and labour

— The Economist, 2010. 3.

Related topics and projects

➤ Near Duplicate Web Video Detection



Related topics and projects

➤ Content-based Image Retrieval (CBIR – iSimilar)



- 1、图书检索 <http://www.isimilar.com:8080/isimilar-web/>
- 2、时尚检索 <http://cloud-a02.zhisuotech.com:8080/cloth/>

Related topics and projects

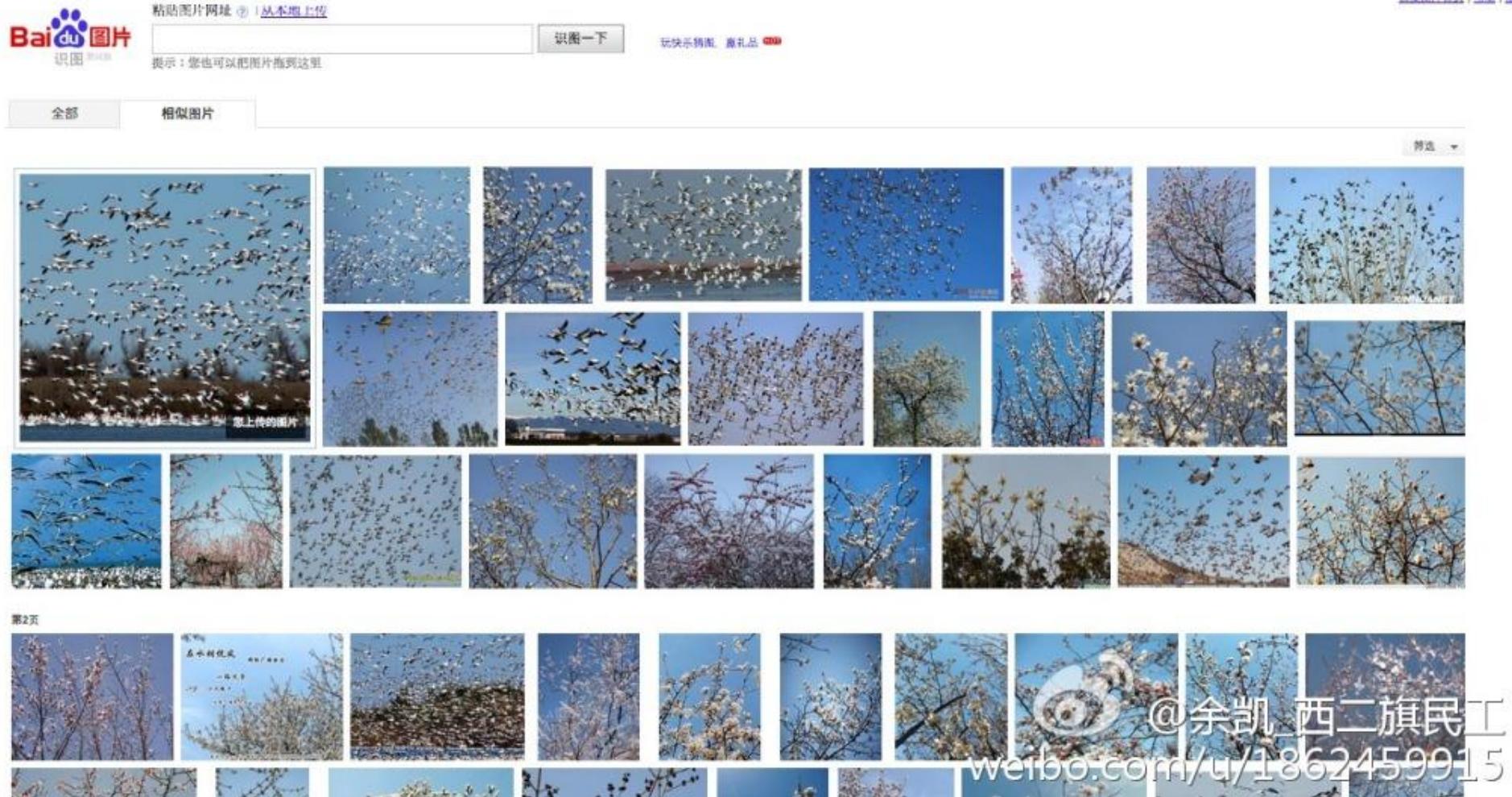
- Content-based Image Retrieval (CBIR – iSimilar)



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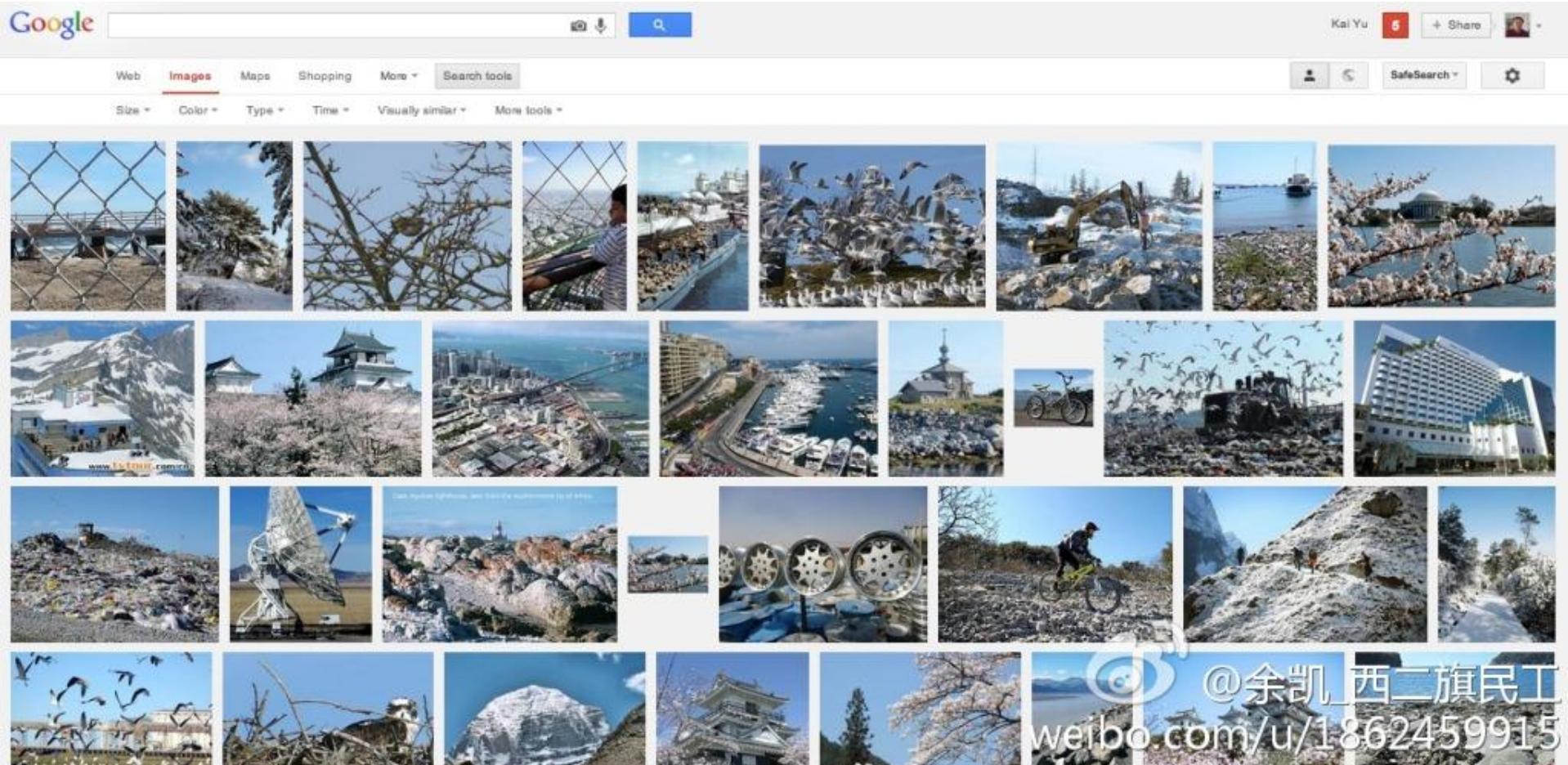
weibo.com/u/1862459915

Related topics and projects



Related topics and projects

➤ Content-based Image Retrieval (CBIR – iSimilar)



手机百度客户端
Baidu Mobile Search APP

为你写诗

诗意指数 **65** 分

范进是为了给你写诗才疯的



铁打长城牢捍海，九州大地风寒天。
千山万水一江秋，万水千山半岭雁。

扫一扫 杜甫来为你写诗！

三亿人都在用的手机百度客户端 ~

@洗水池

weibo.com/joey327



手机百度客户端
Baidu Mobile Search APP

为你写诗

诗意指数 **64** 分

为给你写诗，鲁智深伤透脑筋



旅游灌云大伊山，风流如水小天地。
人生难得几万里，望尽天涯一千年。

扫一扫 杜甫来为你写诗！

三亿人都在用的手机百度客户端 ~

@洗水池

weibo.com/joey327



手机百度客户端
Baidu Mobile Search APP

为你写诗

诗意指数 **71** 分

照顾好七舅姥爷，小六为你写

踏边蒙古大草原，拂面风来小河湾。
帷幄运筹惊情处，雄才大略觉意间。

扫一扫 杜甫来为你写诗！
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weibo.com/joey327

手机百度客户端
Baidu Mobile Search APP

为你写诗

诗意指数 **75** 分

五花肉千金妞，不及汪伦为你写诗

喀纳斯湖长啸傲，山风轻拂短歌行。
流水东去多惬意，清风北来有闲情。

扫一扫 杜甫来为你写诗！
三亿人都在用的手机百度客户端 ~
weibo.com/joey327

Chapter 1 Introduction

手机百度客户端
Baidu Mobile Search APP

为写诗

诗意指数 **100 分**
李白戒酒跪求为你写诗



醉抱美人共出浴， 清风明月同升华。
明月清风远俗尘， 高山流水清清水。

扫一扫 杜甫来为你写诗！
三亿人都在用的手机百度客户端 ~

 @洗水池
weibo.com/joey327

手机百度客户端
Baidu Mobile Search APP

为写诗

诗意指数 **65 分**
范进是为了给你写诗才疯的



同学聚会兴浓稠， 相识相逢相逢秋。
无情风雨人间事， 有意云烟万里愁。

扫一扫 杜甫来为你写诗！
三亿人都在用的手机百度客户端 ~

 @洗水池
weibo.com/joey327

手机百度客户端
Baidu Mobile Search APP

为写诗

诗意指数 **75** 分

五花肉千金妞，不及汪伦为你写诗



美食羊肉面，一碗做神仙。
山水迷人眼，水波映碧天。

扫一扫 杜甫来为你写诗！

三亿人都在用的手机百度客户端 ~

@洗水池

weibo.com/joey327



手机百度客户端
Baidu Mobile Search APP

为写诗

诗意指数 **65** 分

范进是为了给你写诗才疯的



陵树无根秋草中，白云有意落花风。
清风明月不知人，明月清风何处梦。

扫一扫 杜甫来为你写诗！

三亿人都在用的手机百度客户端 ~

@洗水池

weibo.com/joey327



Question: what do we need to do to accomplish an image search engine?

- 7、医学图像处理(和三院康复科合作)
- 8、目标识别与跟踪、事件分析(安防监控)
- 9、遥感卫星图像、气象云图等
- 10、请自己给出一个生活中和图像处理有关的例子



Chapter 1

Introduction 背景简介

Preview

- 1. What Is Digital Processing**
- 2. The Origins of Digital Image Processing**
- 3. Examples of Fields that Use Digital Image Processing**
- 4. Fundamental Steps in Digital Image Processing**
- 5. Components of an Image Processing System**

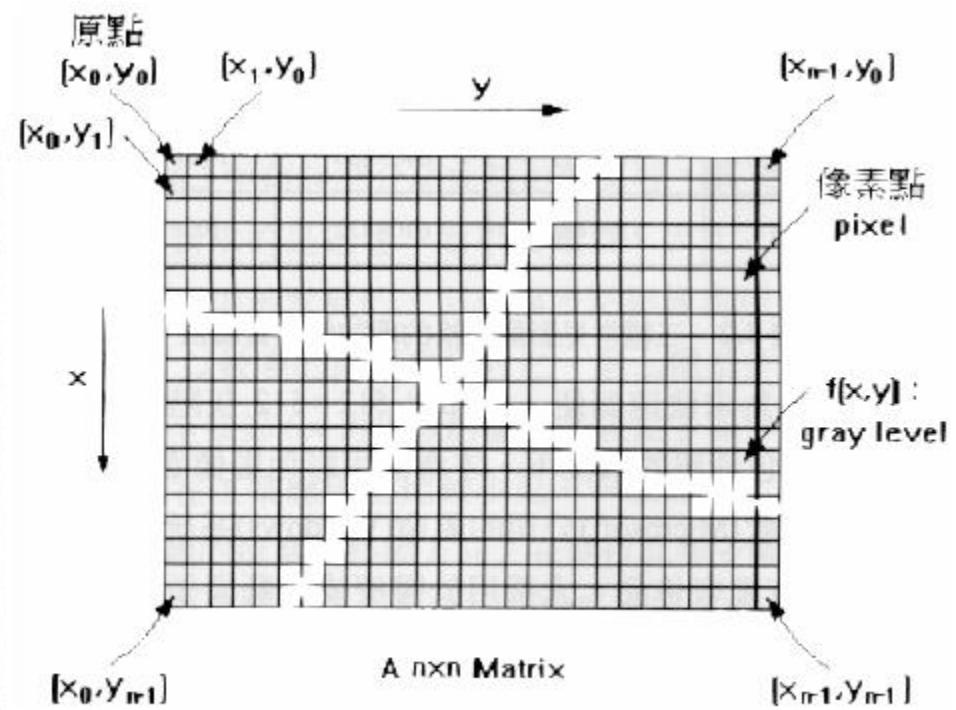
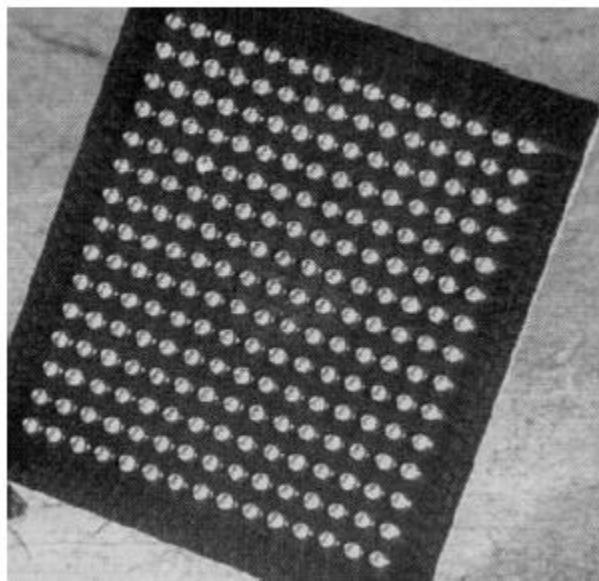
1.1 What Is Digital Image Processing

◆ What is digital image?



A digital image can be considered as a two-dimensional function, or a two-dimension matrix $f(x, y)$, where x and y are spatial coordinates, and the value of $f(x, y)$ is the intensity or gray level (or color) of the image at that point.

Digital image processing means processing digital images by means of digital computers.



◇ How to view a digital image

$$f(x, y) =$$



Homework01

◇ Related areas

- Image Processing and Video Processing
- Image Analysis (Understanding)
- Pattern Recognition
- Computer Vision

Image Processing —— Image Understanding

—— Computer Vision

- **Low-level Processing:** both input and output are images
 - Noise Reduction
 - Image Enhancement
 - Image Sharpening
- **Mid-level Processing:** input images, output attributes of those images
 - Image Segmentation
 - Image Indexing (Feature Extraction)
- **High-level Processing:** related to computer vision
 - Image Analysis and Understanding

◆ Main Application Areas

- Improvement of pictorial information to help human interpretation, such as X-ray images for medical purposes, satellite images
- Processing of image data for storage, transmission (video conference), and representation for autonomous machine perception.

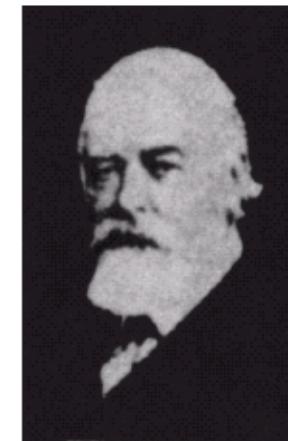
1.2 The Origins of Digital Image Processing

- One of the first application of digital images was in the newspaper industry at early 1920s



Digital picture
produced in 1921 From
a coded tape by a
telegraph printer
3 Hours transmission

- Binary image produced by punched tape in 1922
- Error occurs during transmission



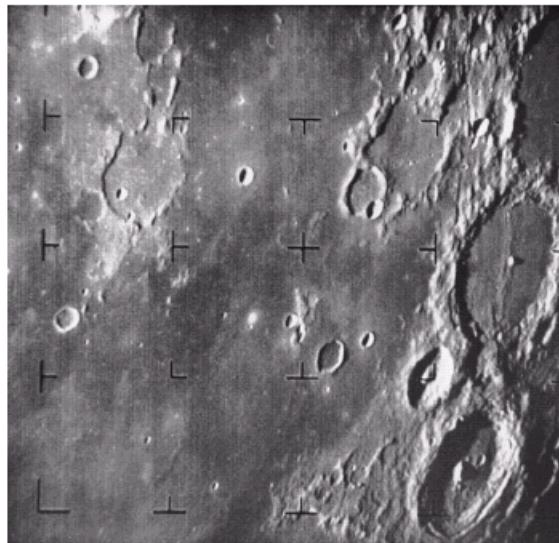
1929 15-tone
image used in
cable
transmission
from London
to New York



● Important and fundamental steps from 1920s

- 1948, invention of *transistor* at Bell Laboratory
- Development of *high-level programming languages* from 1950s
- 1958, the invention of *Integrated Circuit* (IC) by TI
- The development of *operating system* in early 1960s
- The development of *Microprocessor* by Intel
- 1981, *personal computer* by IBM
- Progressive miniaturization starting from 1970s. LI , VLSI & ULSI
(超 (特) 大规模集成电路)

- Early 1960s, first computer powerful enough to carry out meaningful image processing tasks appeared.
- Space applications (Apollo missions, etc.)
- Medical applications (X-ray CT and so on)
- Machine perceptions



- 1964 Using computer to improve image quality
- Image of the Moon taken by Ranger 7 on July 31, 1964 at 9:09AM.
(8 bits, 256 tone)



2 levels



4 levels



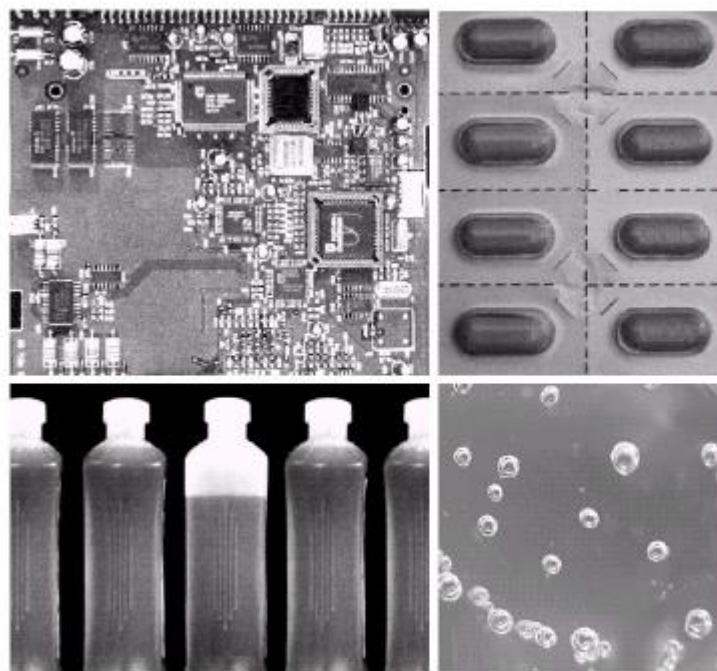
256 levels

1.3 Examples of Fields Using Digital Image Processing

- Bio-medical imaging: X-ray, CT (Computed Tomography), MRI (Magnetic Resonance Imaging), PET (Positron Emission Tomography), angiogram (血管造影) , ultrasound, microscopy.
- Industry: PC board inspection, wafer inspection, IC-pin inspection, in-plant inspection, Robot vision, SEM (Scanning Electron Microscope).
- Satellite imaging: LANDSAT (地球资源探测卫星) , NOAA GEOS, SAR (国家海洋和大气局大地测量卫星) .
- Surveillance: DVR, ITS, military.
- Multimedia: e-commerce, e-learning, videoconferencing, entertainment.

1.3 Examples of Fields Using Digital Image Processing

- Industry: PC board inspection, wafer inspection, IC-pin inspection, in-plant inspection, Robot vision, SEM (Scanning Electron Microscope).



Examples of Automatic
Inspection

- (a) PCB (SMT)
- (b) Piles (missing pile)
- (c) Volume

1.4 Fundamental Steps in Digital Image Processing

Chap. 2 Image Acquisition

Chap. 3 & 4 Image Enhancement

Chap. 5 Image Restoration

Chap. 6 Color Image Processing

Chap. 7 Wavelet transform

Chap. 8 Image Compression

Chap. 9 Morphological Processing

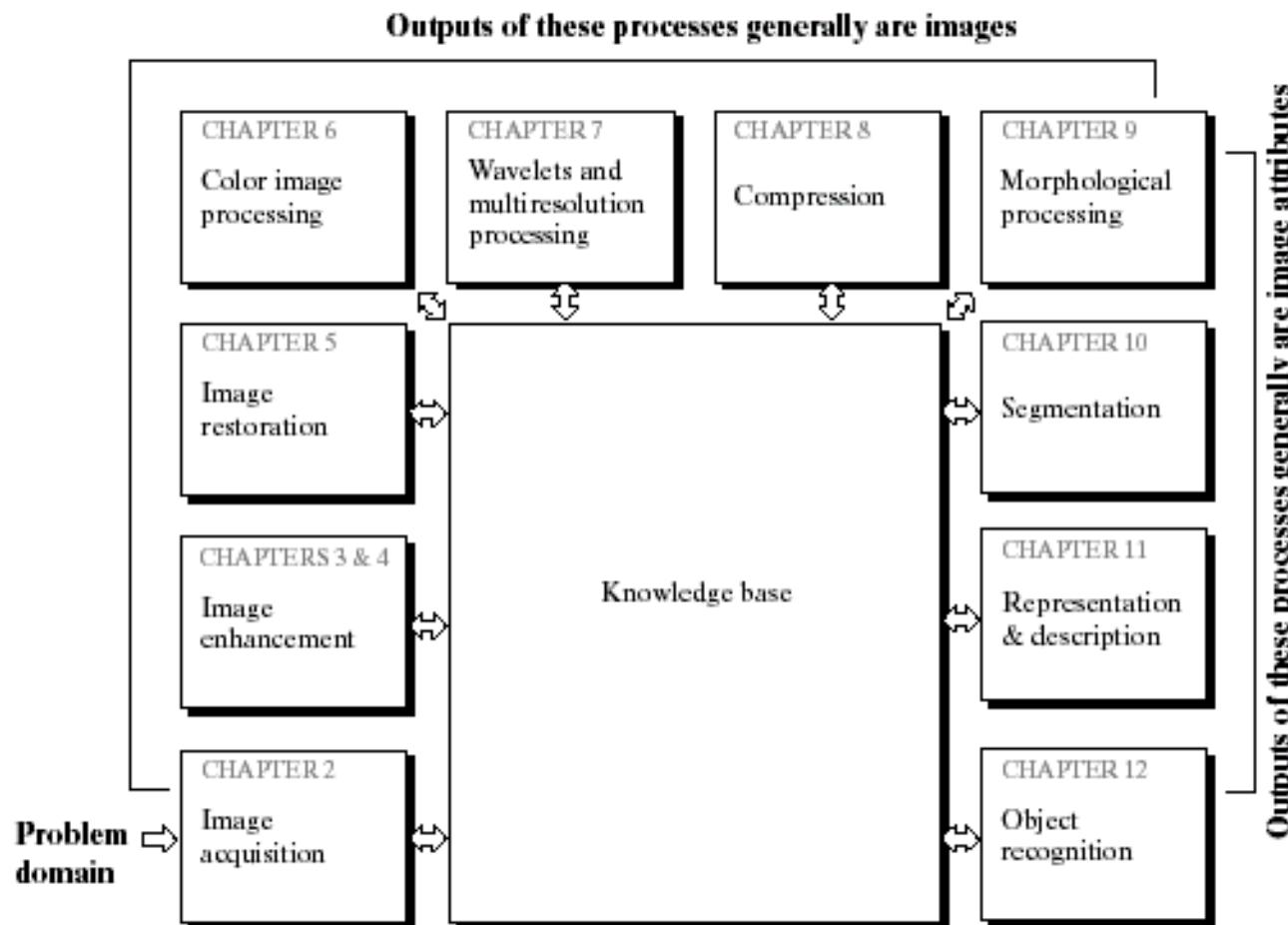
Chap. 10 Image Segmentation

Chap. 11 Representation and Description

Chap. 12 Recognition

1.4 Fundamental Steps in Digital Image Processing

FIGURE 1.23
Fundamental
steps in digital
image processing.



1.5 Components of an Image Processing System

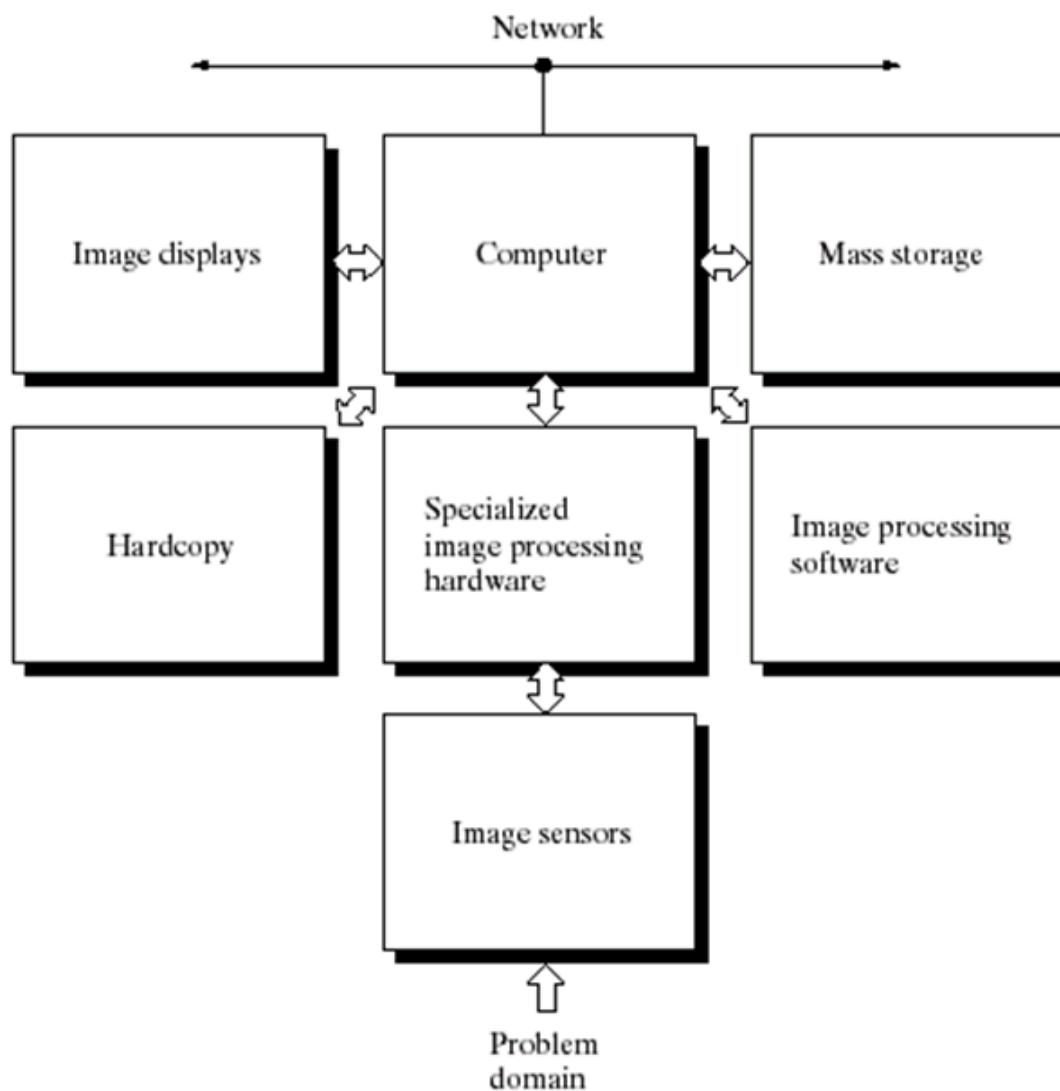


FIGURE 1.24
Components of a general-purpose image processing system.

任何图像本质上就是一个二维函数, x 和 y 是空间坐标, 在任何一对空间坐标上的函数值称为该点的强度或灰度. 当 x , y 和幅值为有限的、离散的数值时, 就称这个图像为数字图像.

换一种说法, 数值图像从数学的角度其实就是一个二维矩阵

那么, 所有代数里学过的矩阵处理方法都可以尝试?

图像处理—图像分析(理解)—计算机视觉 (语义层)

本书界定图像处理包括输入输出均为图像的处理, 也包括从图像中提取信息及识别特定物体的处理.