

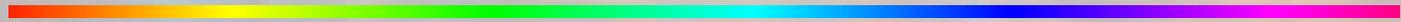
# Technical English

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For Information and Communication  
Engineering

2011/9/11

# Unit Two



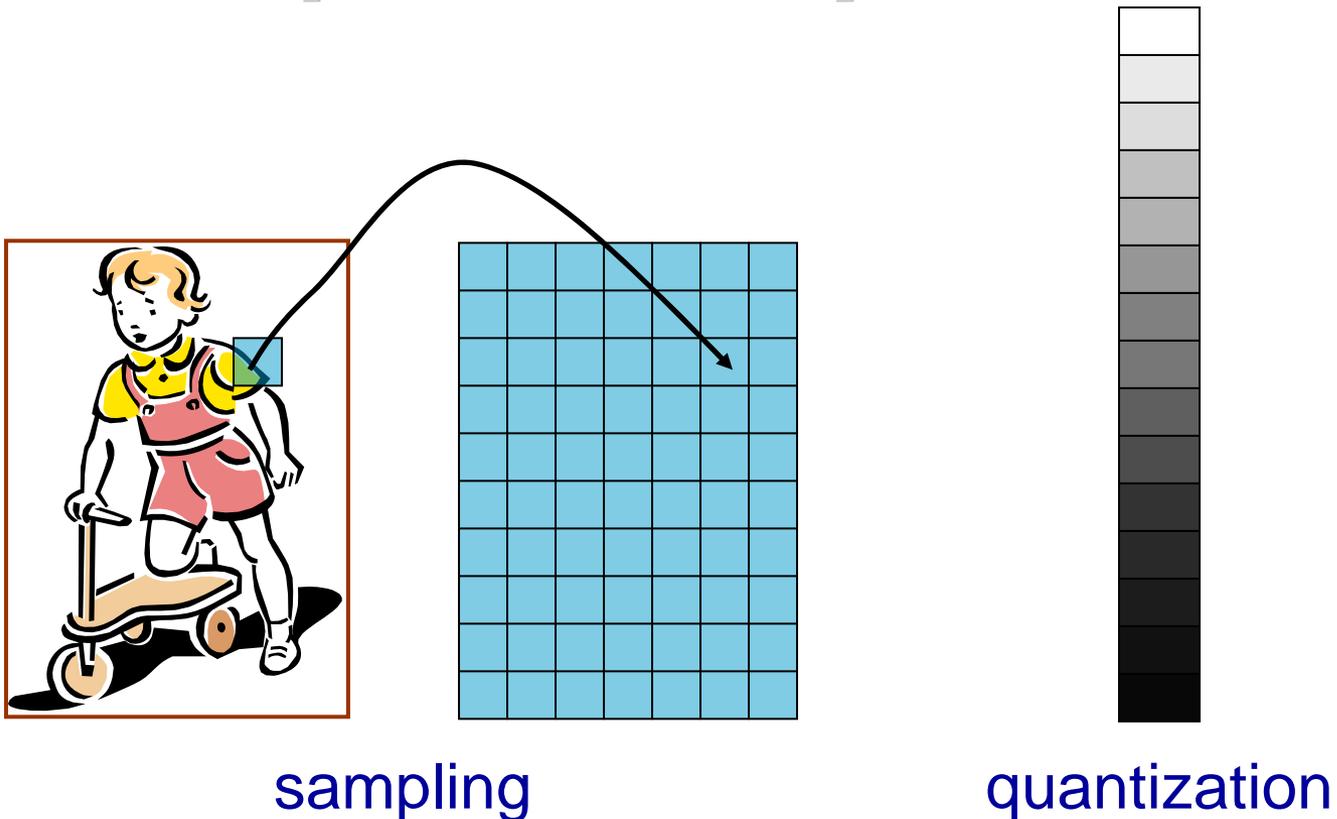
Introduction to Digital Image  
Processing



# 数字图像处理简介

**Digital image: a 2D rectangular array of quantized samples.**

- **Sampled in an equally spaced rectangular grid pattern**
- **Quantized in equal intervals of amplitude.**





scene	景，场景
enhancement	增强
wherein	在那（哪）方面
radiance	光辉，发光
autonomous	自治的，自主的
intensity	强度
comprise	包含，构成
sensor	传感器，感应器
comparable	可比的
underappreciated	认识不足的
novice	新手，初学者
engineer	设计，策划
spreadsheet	电子表格
constraint	约束，限制
impose	施加



camcorder	手持摄像机
monochrome	单色的
dreaded	可怕的
curse	诅咒, 咒语
ambient	周围的
spectrum	频谱, 光谱
strobe	闪光
decent	得体的, 适当的
immune	免疫的, 免受影响的
contrast	对比度, 反差
photometric	光度的
calibration	校准
matte	表面粗糙的 (matt, mat)
specularly	镜面反射地
diffuse	扩散的, 散开的



acquisition	获取
shutter	照相机快门
exposure	曝光
prohibitive	禁止的，不可忍受的
perceptual	知觉的，感官的
robust	强健的，鲁棒的
logarithmic	对数的
hue	色彩，色度
dedicated	专用的，定制的
advent	到来
de facto	事实上的
merchant	商人，商业的
vendor	供应商
time-critical	对时间要求很严的



由各种物理设备产生

用于各种目的

Images are **produced by a variety of physical devices**, including still and video cameras, x-ray devices, electron microscopes, radar, and ultrasound, **and used for a variety of purposes**, including entertainment, medical, business (e.g., documents), industrial, military, civil (e.g., traffic), security, **and scientific**. The goal in each case is for an observer, **human or machine**, to extract useful information about the scene being imaged.

插入语



不直接适合于..., 必须进行某种处理

Often the raw image **is not directly suitable** for this purpose, **and must be processed in some way**. Such processing is called *image enhancement*; processing by an observer to extract information is called *image analysis*. Enhancement and analysis are **distinguished by their output, images vs. scene information, and by the challenges faced and methods employed**.

vs.= versus

根据其输出性质即输出的是图像还是关于场景的信息来区分, 也根据所面临的挑战和所使用的方法来区分。



**Image enhancement has been done by chemical, optical, and electronic means, while analysis has been done mostly by humans and electronically.**

而



一个子集，它将图像转换成整数阵列，这些称为像素的整数代表某一物理量如景物的辐射，

Digital image processing is a subset of the electronic domain wherein the image is converted to an array of integers, called *pixels*, representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware.

被存放在数字存储器中，然后用计算机或其他数字硬件进行处理。



无论是为观察者便于观看的图像增强  
还是进行（计算机）自主分析

**Digital image processing, either as enhancement for human observers or performing autonomous analysis, offers advantages in cost, speed, and flexibility, and with the rapidly falling price and rising performance of personal computers, has become the dominant method in use.<sup>1</sup>**

随着个人计算机价格的急剧下降和功能的快速提升而成了实用的主要方法



## 被观察的物理对象性质的直接测量

An image is not a direct measurement of the properties of physical objects being viewed. Rather it is a complex interaction among several physical processes: **the intensity and distribution** of illuminating radiation, **the physics** of the interaction of the radiation with the matter comprising the scene, **the geometry** of projection of the reflected or transmitted radiation from 3 dimensions to the 2 dimensions of the image plane, and **the electronic characteristics** of the sensor.<sup>2</sup>

4种物理过程: **the intensity and distribution, the physics, the geometry, and the electronic characteristics**



不同于其他任务例如编写编译器那样有基于正式理论的算法将高级计算机语言翻译成机器语言

Unlike for example writing a compiler, where an algorithm backed by formal theory exists for translating a high-level computer language to machine language, **there is no algorithm and no comparable theory for extracting scene information of interest, such as the position or quality of an article of manufacture, from an image.**

不存在从图像中提取感兴趣景物信息 ... 的（现成）算法和可（与编译理论）相比的理论



因为人的视觉系统似乎可轻而易举地从景物中提取信息。

The challenge is often **underappreciated** by novice users **due to** the seeming effortless with which their own visual system extracts information from scenes.<sup>3</sup> Human vision is enormously more sophisticated than anything we can engineer at present and for the foreseeable future. Thus one must be careful **not to evaluate the difficulty of a digital image processing application on the basis of how it looks to humans.**

不能根据人们对某一种数字图像处理应用的（表面）观察来评估它的难度



精确确定汽车零件在传输带上的位置以及它的大小

Perhaps the first guiding principle is that humans are better at judgment and machines are better at measurement. Thus **determining the precise position and size of an automobile part on a conveyer**, for example, is well-suited for digital image processing, whereas **grading apples or wood** is quite a bit more challenging (although not impossible). Along these lines image enhancement, which generally requires lots of numeric computation but little judgment, is well-suited for digital processing.

将苹果或木材分等级



对处理时间的严格要求常使问题变得更复杂。

**The problem is further complicated by often severe time budgets.** Few users care if a spreadsheet takes 300 milliseconds to update rather than 200, but most industrial applications, for example, must operate **within hard constraints imposed by machine cycle times.** There are also many applications, such as ultrasound image enhancement, traffic monitoring, and camcorder stabilization that require real-time processing of a video stream.

在机器周期所要求的严格限制范围内



在撰写本文时

To make the speed challenge concrete, consider that the video stream from a standard monochrome video camera produces around 10 million pixels per second. **As of this writing** the typical desktop PC can execute maybe 50 machine instructions **in the 100 ns available to process each pixel**. The set of things one can do in a mere 50 instructions is rather limited.

在处理每个像素所允许的100ns时间内



此外，更有甚者

**On top of this** many image processing applications are constrained by severe cost targets. **Thus we often face the engineer's dreaded triple curse, the need to design something good, fast, and cheap all at once.**

因此我们经常面临工程师们望而生畏的三重难题：要求设计的产品同时具备性能优良、运行快捷、价格便宜的优点。



典型的是光线但广义的是某种能量

All image processing applications start with some form of illumination, **typically light but more generally some form of energy**. In some cases ambient light must be used, but more typically the illumination can be designed for the application. In such cases **the battle is often won or lost right here** — no amount of clever software can recover information that simply isn't there due to poor illumination.<sup>4</sup>

事情的成败往往就在于此



可以选择照射强度、方向、光谱（颜色），选择连续照明还是闪光

Generally one can choose illumination intensity, direction, spectrum (color), and continuous or strobed. Intensity is easiest to choose and least important; any decent image processing algorithm should be immune to significant variations in contrast, although applications that demand photometric accuracy will require control and calibration of intensity.

应该不受反差较大变化的影响



从一个极端的点光源到另一极端的“天穹”照明（所有方向强度相等）

**Direction is harder to choose and more important, as any professional photographer knows. The choices range from point sources at one extreme to “sky” illumination (equal intensity from every direction) at the other. In between are various extended sources such as linear and ring lights.**

扩展光源（有一定尺度的光源）



粗糙表面在点光源时表现较好

The goal generally is to produce consistent appearance. As a rule **matte surfaces do better with point sources** and shiny, specularly-reflecting surfaces do better with diffuse, extended sources. A design that allows computer-controlled direction (usually by switching LEDs on and off) is often ideal.

Illumination color can sometimes be used as form of image enhancement. Its primary value is that it is cheap and **adds zero processing time.**

不增加处理时间



**High-speed image acquisition for rapidly moving or vibrating objects may require a strobe. Most cameras have an electronic shutter which is preferable for low to medium speed acquisition, but as the exposure times get shorter the amount of light needed increases **beyond what is reasonable to supply continuously.**<sup>5</sup>**

**超过光源可连续提供的程度**



For our purposes a camera is any device that converts a pattern of radiated energy into a digital image stored in a random-access memory. In the past this operation was divided into two pieces: **conversion of energy to electrical signal**, considered to be the camera's function, and **conversion and storage of the signal in digital form**, performed by a *digitizer*. As of this writing the distinction is becoming blurred, and **before long** cameras will feed directly to computer memory via USB, Ethernet, or IEEE 1394 interfaces.

要不了多久



无例外地受到最大实际应用量的驱动

Camera technology and the characteristics of the resulting images are **driven almost exclusively by the highest volume applications**, which until recently has been consumer television. Thus most visible-light cameras in current use for digital image processing **have resolution and speed characteristics established by TV broadcast standards** almost a half century ago.

具有 ... 电视广播标准所确立的分辨率和速度指标



任意时刻回复到一帧初始状态的能力，从而可避免在开始捕获一帧新图象前的等待

As of this writing the typical visible light monochrome camera would have a resolution of  $640 \times 480$  pixels, produce 30 frames per second, and support electronic shuttering and rapid reset (the ability to reset to the beginning of a frame at any time, to avoid having to wait before beginning an image acquisition).<sup>6</sup> It would be based on CCD sensor technology, which produces good image quality but is expensive relative to most chips with a similar number of transistors.



也有分辨率和速度高得多的器件，但通常极为昂贵。

**Significantly higher resolution and speed devices are available but often prohibitively expensive. An alternative is the *line-scan* camera, which uses a one-dimensional sensor and relies on scene motion to produce an image.**



情况首次发生了变化

**For the first time ever the landscape is changing**, as high volume personal computer multimedia applications proliferate. First affected were monitors, which for some time have offered higher-than-broadcast speed and resolution. One can expect cameras to follow, **with high-speed, high-resolution devices driven by consumer digital still camera technology** and **lower-resolution, ultra low cost units driven by entertainment, internet conferencing, and perceptual user interface applications.**<sup>7</sup>

由民用数字照相机所推动的高速度、高分辨率器件，以及由娱乐业、互联网远程会议和用户视觉界面应用所推动的低分辨率和极低价格的设备



仅仅由于生产批量较大

The low cost devices may have the greater influence. These are based on emerging CMOS sensor technology, which uses the same process as most computer chips and is therefore inexpensive **due simply to higher process volume. Currently image quality is not up to CCD standards, but that is certain to change as the technology matures.**<sup>8</sup>

目前它的图象质量还达不到CCD标准，但随着技术的成熟是注定会改进的。



主要由于照相机价格和数据处理量的负担

Although monochrome images have almost entirely disappeared in consumer applications, they still represent the majority in digital image processing **due primarily to camera cost and data processing burden** (for color those 50 instructions per pixel would drop to 17). Color cameras come in two forms: single sensor devices that alternate red, green, and blue pixels in some pattern, and **much higher quality but more expensive devices with separate sensors for each color.**

质量更好但却更昂贵的各颜色分量分别使用单独感光单元的器件



要求细致的设计以从信号中得到多于8比特的有用数据

Monochrome pixels are usually 8 bits (256 gray levels), although 10- and 12-bit devices are sometimes used. Video signals tend to be noisy, however, and **careful engineering is required to get more than 8 useful bits out of the signal.** Furthermore, robust image analysis algorithms do not rely on photometric accuracy, so unless the application calls for accurate measurements of scene radiance, **there is usually little or no benefit beyond 8 bits.** Wide dynamic range is more useful than photometric accuracy, but it is usually best achieved by using a logarithmic response than by going to more bits.

8比特以上的精度通常没有实际意义



这是一个人的生理学现象而不是物理现象

Color pixels are 3-element vectors (**this is a fact of human physiology, not physics**). Several representations, called *color spaces*, are commonly used for representing color. The simplest to produce is the {red, green, blue} space (RGB), although {hue, intensity, saturation} space (HIS) may be more useful for image analysis. For the lower quality single-sensor cameras, the {luminance, chroma1, chroma2} space (YCC) is sometimes used.



专用硬件

Until recently the computational burden of digital image processing for the most part had to be handled by **dedicated hardware**. Typically such hardware consisted of plug-in cards for PCI and/or VME backplanes, containing one or more **application-specific integrated circuits** (ASICs) designed for digital image processing.

专用集成电路



## 从专用硬件向纯软件解决方案的转变

The last few years has seen a move away from dedicated hardware towards pure software solutions, due to the advent first of DSPs and later general-purpose CPUs that fall at or above the 1 billion operations per second mark. Of these the most significant is the development of MMX processors by Intel Corporation.

处于或超越每秒10亿次运算速度界限



虽然不能单独起到这一作用

MMX technology is well-suited for digital image processing. **Although it is hardly alone in being so**, MMX is so widely available (all Intel-compatible PCs made since 1997) that it is the **de facto standard** for merchant digital image processing software. This development is likely to solidify with the expected introduction sometime in 2000 on Merced processors of **EPIC** technology, **jointly developed by Intel and Hewlett-Packard**. The **EPIC** architecture is superb for digital image processing.

**Explicitly Parallel Instruction Computing**



只能被熟练的汇编语言编程人员所用

The full power of the new processors is generally **available only to skilled assembly language programmers**, and this is unlikely to change in the foreseeable future. Compiler vendors and the EPIC architects may argue otherwise, but direct experience in high-performance digital image processing has consistently shown this. **For time-critical applications**, users should turn to specialists.

对于时间要求苛刻的应用



## 结合课文的思考题

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- **What are the objectives of image enhancement and image analysis?**
- **Why are the difficulties in extracting information from images often underappreciated?**
- **What are the merits and disadvantages in image processing using hardware and software approaches, respectively?**

# Exercises



- Although some communication signals are inherently digital in nature, many signals are analog, or smooth, function of time.
  - A. are essentially of digital characteristics
  - B. are inevitably in a digital form existing in the nature
  - C. are naturally considered as digital
  - D. are mainly in a digital nature



# Exercises

- Any small deformations in the height or width of the pulses are irrelevant since it is only necessary to know whether the pulse is present or absent in order to retrieve the original message.
  - A. to reform the original information
  - B. to recover the original signal
  - C. to re-obtain the original information
  - D. to represent the original signal



# Exercises

- Artificial intelligence is the attempt to build computational model of cognitive processes or put it another way: in artificial intelligence we make computers perform tasks that would be considered intelligent if done by a human.
  - A. computer simulation of pattern recognition
  - B. representation of understanding in terms of computer language
  - C. computerized characterization of digital processing
  - D. mode of performing tasks with computer



# Exercises

- A salient feature of computer graphics is that the computer can synthesize objects which do not exist in the real world.
  - A. the computer can analyze objects
  - B. the computer can synchronize with objects
  - C. the computer can organize objects
  - D. the computer can make up objects



# Exercises

- Assembly language is a machine-specific language that uses symbolic instructions rather than the binary equivalents in the machine language for that machine.
  - A. special machine language
  - B. language applicable to particular processors
  - C. language installed in a specific machine
  - D. language independent of any computer



# Exercises

- As speech exists originally in the space, it is multidimensional in nature. In other words, a speech signal is a function of four variables — three space variables and time.
  - A. it is multidimensional in the nature
  - B. it is mainly multidimensional
  - C. its characteristic is multidimensional
  - D. it is naturally multidimensional



# Sentence translation

- The goal in each case is for an observer, human or machine, to extract useful information about the scene being imaged.
- Enhancement and analysis are distinguished by their output, images vs. scene information, and by the challenges faced and methods employed.
- In the system, the image is converted to an array of integers, called pixels, representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware.
- No amount of clever software can recover information that simply isn't there due to poor illumination.
- These are based on emerging CMOS sensor technology, which uses the same process as most computer chips and is therefore inexpensive due simply to higher process volume.