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Image Processing

معالجة الصور

إعداد

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Image Processing

1-1Introduction

The visual experience is the principal way that humans sense and communicate with their world. A visual beings and images are being made increasing available in electronic digital format via digital cameras, the internet, and hand-held devices with large-format screens. With much of the technology being introduced to the consumer marketplace being rather new, digital image processing remains a “hot” topic and promises to be one for a very long time. Of course, digital image processing has been around for quite awhile, and indeed, methods pervade nearly every branch of science and engineering. One only has to view the latest space telescope images or read about the newest medical image modality to be aware of this.

1.2 Computer Vision

Computer vision emulate human vision, that’s mean: understanding the scene based on image data. One of the major topics within this field of computer vision is image analysis.

1. Image Analysis: involves the examination of the image data to facilitate solving vision problem.

The image analysis process involves two other topics:

- Feature Extraction: is the process of acquiring higher level image information, such as shape or color information.
- Pattern Classification: is the act of taking this higher –level information and identifying objects within the image.

Computer vision systems are used in many and various types of environments, such as:

1. Manufacturing Systems: computer vision is often used for quality control, where the computer vision system will scan manufactured items for defects, and provide control signals to a robotics manipulator to remove detective part automatically.

2. Medical Community: current example of medical systems to aid neurosurgeons during brain surgery, systems to diagnose skin tumors automatically.
3. The field of Law Enforcement and security in an active area for computer vision system development, with application ranging from automatic identification of fingerprints to DNA analysis.
4. Infrared Imaging.
5. Satellites Orbiting.

1-3Digital Image Processing

Digital image processing is a high growth sector fed by the rapidly falling costs of the hardware (computers, scanners, digital cameras, etc.) and the availability of quality image processing software. Extracting information about the content of the image is part from the aim of image processing. For example examining a blood sample under a microscope to automatically count the number of white blood cells or examining an image of a road scene to pick out the number and type of road signs present. These applications generally require more advanced techniques such as image segmentation followed by pattern recognition.

1-4Image Processing Application

The digital image processing is a general term for a wide range of techniques that exists for manipulating and modifying images in various ways. Figure (1.1) represent some Applictions of digital image processing.

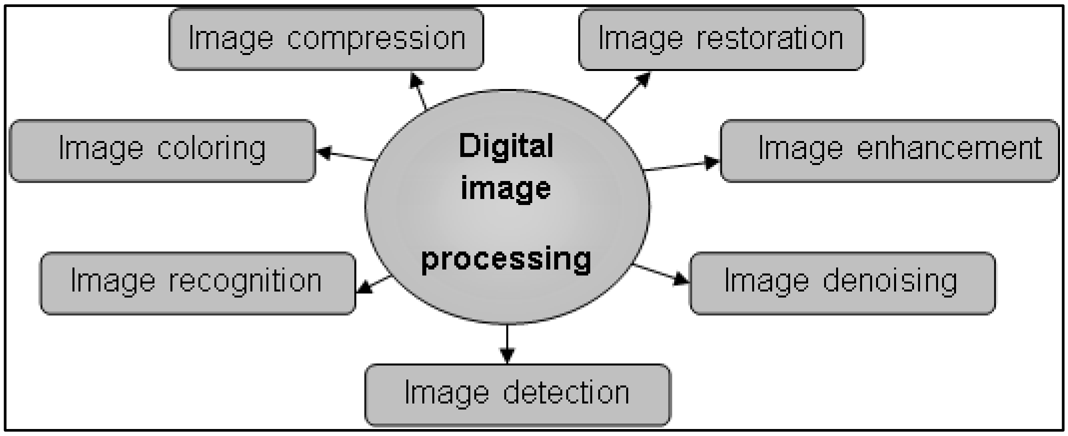


Figure (1-1) : Application of digital image processing

1-4-1Image Restoration

Is the process of taking an image with some known, or estimated degradation, and restoring it to its original appearance. Image restoration is often used in the field of photography or publishing where an image was somehow degraded but needs to be improved before it can be printed (Figure 1.2).

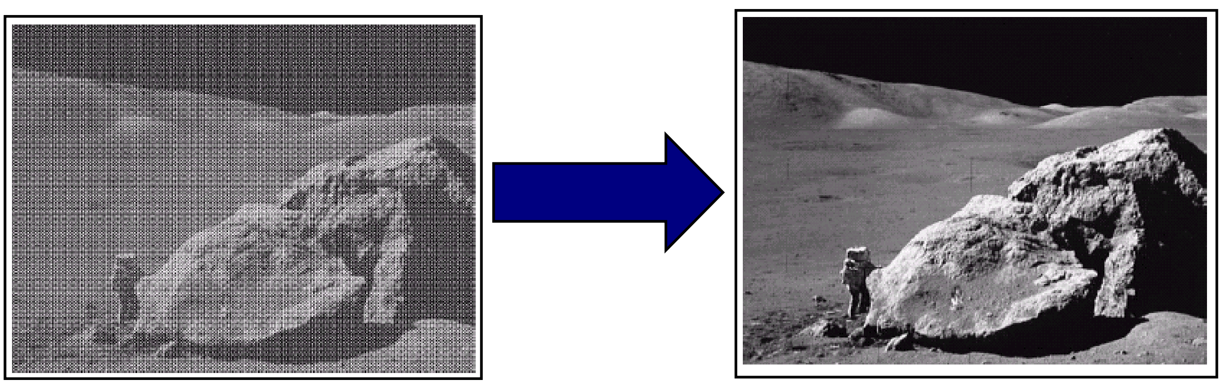


Figure (1.2) Image Restoration

1-4-2Image Enhancement

Involves taking an image and improving it visually. One of the simplest enhancement techniques is to simply stretch the contrast of an image.

Enhancement methods tend to be problem specific. For example, a method that is used to enhance satellite images may not suitable for enhancing medical images.

Although enhancement and restoration are similar in aim, to make an image look better. Restoration method attempt to model the distortion to the image and reverse the degradation, where enhancement methods use knowledge of the human visual systems responses to improve an image visually.(Figure 1.3)

Figure (1.3) : Image Enhancement with Different level of contrast

1-4-3Image Denoising

Images are often corrupted by additive noise. Thus, it is an important problem to recover the signal by removing the noise with minimum signal distortion. Since edges are among the most important features of image, the aim of denoising techniques tailored towards preserving the sharpness of these features.(Figure 1.4)

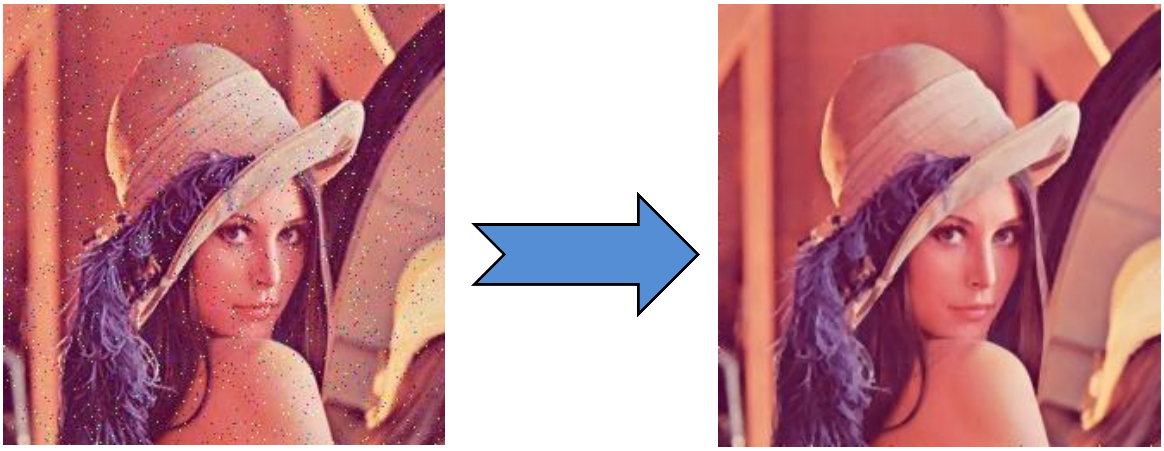


Figure 1.4:Represent Lena.jpg with noisy image and Denoising Image.

1-4-4Image Compression

Involves reducing the typically massive amount of data needed to represent an image. This done by eliminating data that are visually unnecessary and by taking advantage of the redundancy that is inherent in most images. Image data can be reduced 10 to 50 times, and motion image data (video) can be reduced by factors of 100 or even 200.

		
Original		Compression 27:1

Figure 1.4:Represent Image with Compression ratio equal 27 to1.

1-5 Computer Imaging Systems

Computer imaging systems are comprised of two primary components types, hardware and software. The hardware components can be divided into image acquiring sub system (computer, scanner, and camera) and display devices (monitor, printer).The software allows us to manipulate the image and perform any desired processing on the image data.

1-6DIMENSION OF IMAGES

An important feature of digital images and video is that they are multidimensional signals, meaning that they are functions of more than a single variable. The signals are usually 1D functions of time. Images, however, are functions of two and perhaps three space dimensions, whereas digital video as a function includes a third (or fourth) time dimension as well. The dimension of a signal is the number of coordinates that are required to index a given point in the image. A consequence of this is that digital image processing, and especially digital video processing, is quite data-intensive, meaning that significant computational and storage resources are often required.(Fig. 1.5)

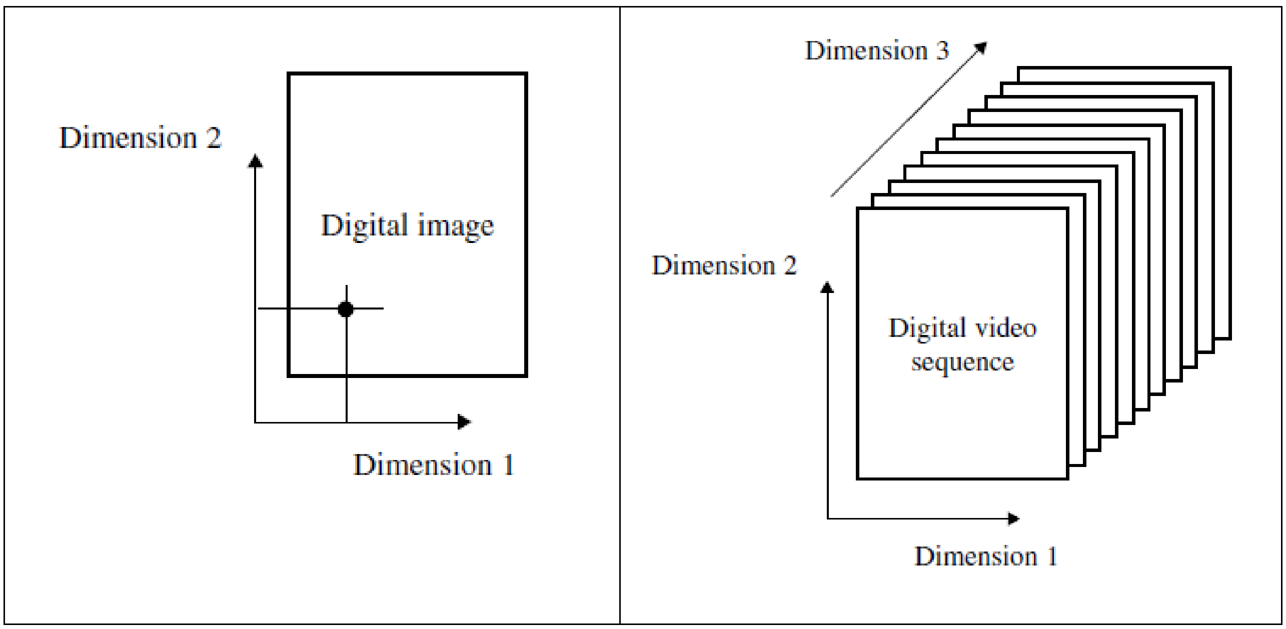


Figure 1.5 : The dimensionality of images and video.

1-7 SAMPLED IMAGES

Sampling is the process of converting a continuous-space (or continuous-space/time) signal into a discrete-space (or discrete-space/time) signal. The sampling of continuous signals is a rich topic that is effectively approached using the tools of linear systems theory. The mathematics of sampling. it is sample a signal sufficiently densely.

For a continuous signal of given space/time dimensions, there are mathematical reasons why there is a lower bound on the space/time sampling frequency (which determines the minimum possible number of samples) required to retain the information in the signal. However, image processing is a visual discipline, and it is more fundamental to realize that what is usually important is that the process of sampling does not lose visual information. Simply stated, the sampled image/video signal must "look good," meaning that it does not suffer too much from a loss of visual resolution or from artifacts that can arise from the process of sampling.(Figure 1.6)

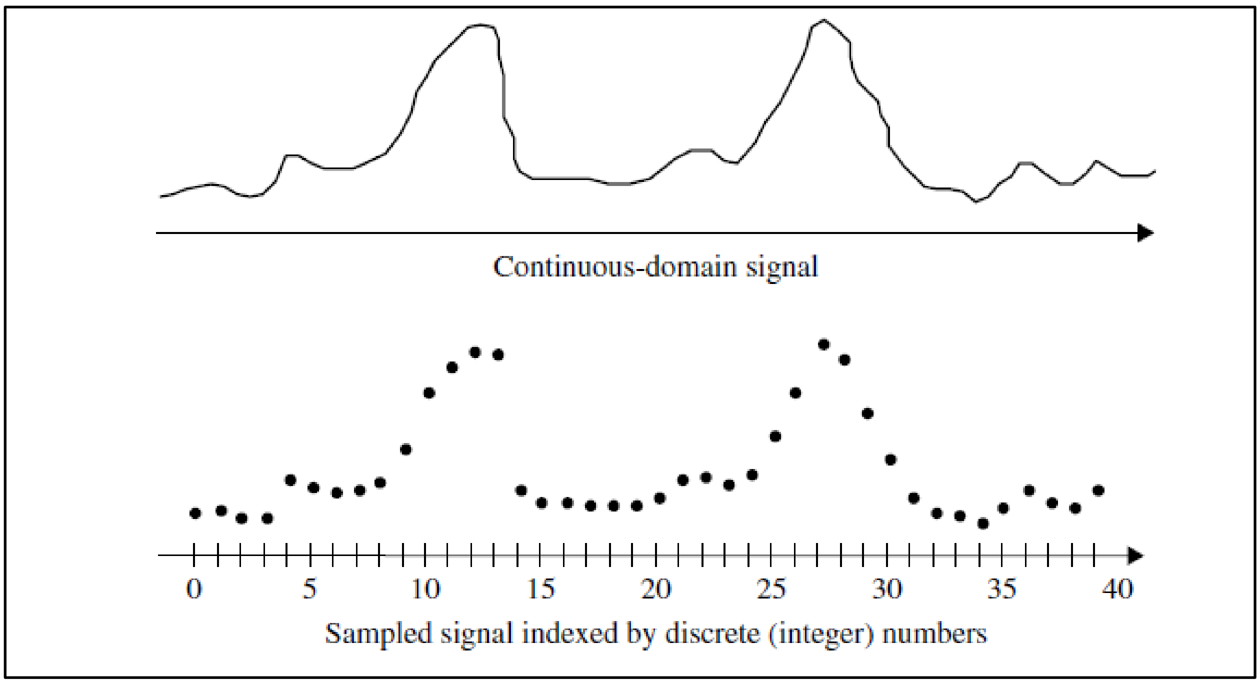


Figure 1.6: Sampling a continuous-domain one-dimensional signal.

The samples collectively describe the gross shape of the original signal very nicely, but that smaller variations and structures are harder to discern or may be lost. Mathematically, information may have been lost, meaning that it might not be possible to reconstruct the original continuous signal from the samples.

The samples are indexed by integer numbers. In fact, the sampled signal can be viewed as a vector of numbers. If the signal is finite in extent, then the signal vector can be stored and digitally processed as an array, hence the integer indexing becomes quite natural and useful. Likewise, image signals that are space/time sampled are generally indexed by integers along each sampled dimension, allowing them to be easily processed as multidimensional arrays of numbers. (Figure 1.7)

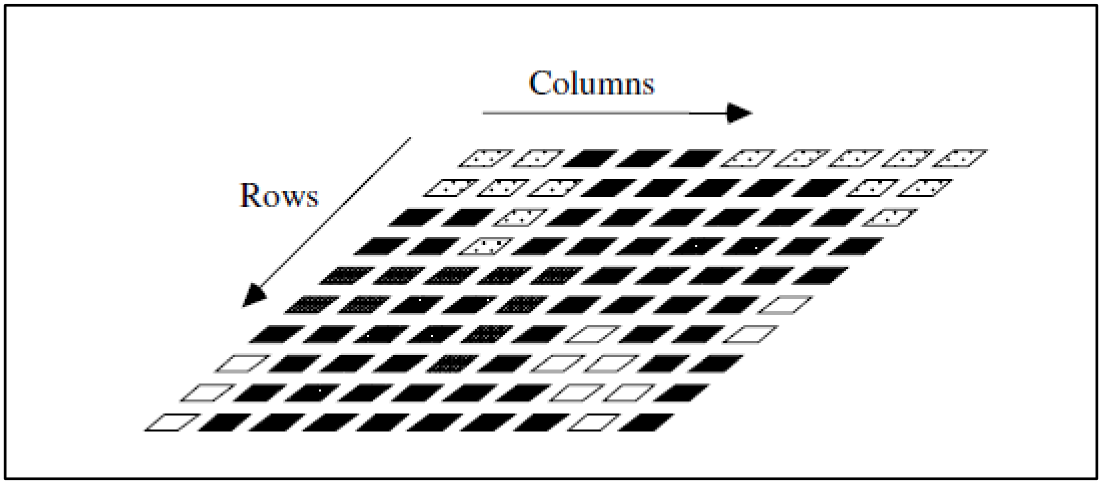


Figure 1.7: Depiction of a very small (10*10) piece of an image array.

A sampled image is an array of sampled image values that are usually arranged in a row-column format. Each of the indexed array elements is often called a picture element, or pixel for short. The number of rows and columns in a sampled image is also often selected to be a power of 2, since it simplifies computer addressing of the samples.

The effects of insufficient sampling (“undersampling”) can be visually obvious. Figure 1.8 shows two very illustrative examples of image sampling. The two images, which we will call “mandrill” and “fingerprint,” both contain a significant amount of interesting visual detail that substantially defines the content of the images, all three scales of images are digital, and so there is potential loss of information relative to the original analog image. However, the perceptual quality of the images can easily be seen to degrade rather rapidly.

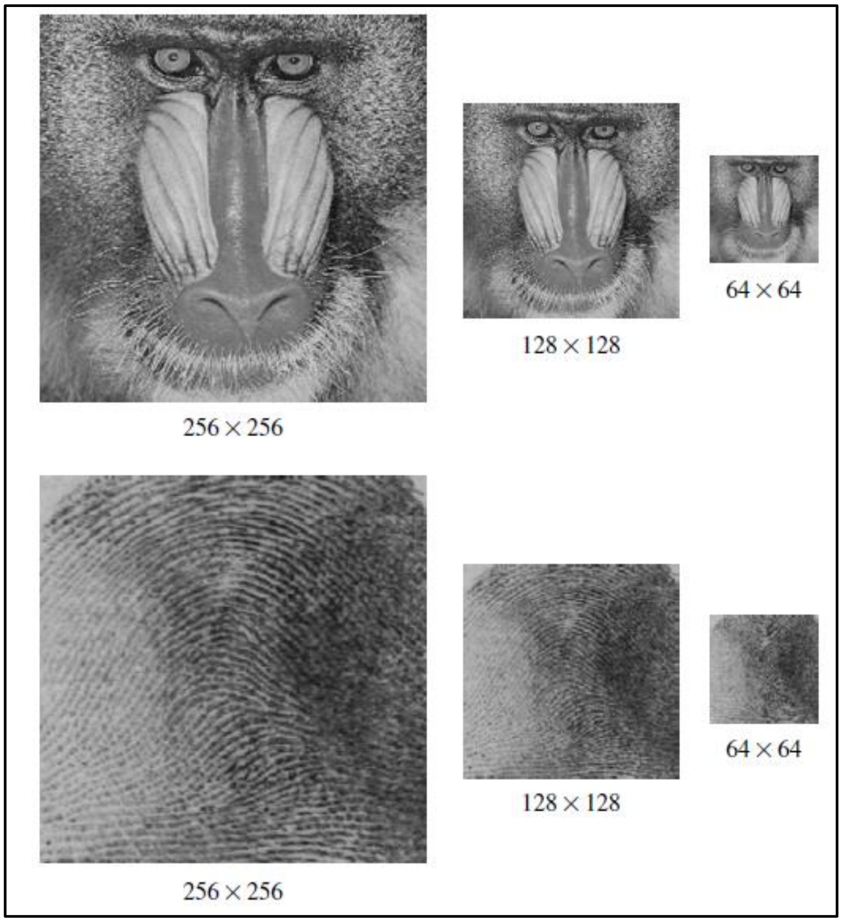


Figure 1.8: Examples of the visual effect of different image sampling densities.

The image can now be accessed as a two-dimension array of data , where each data point is referred to a pixel (picture element).for digital images we will use the following notation :

I(r,c) = The brightness of image at the point (r,c) Where r= row and c= column.

“When we have the data in digital form, we can use the software to process the data”.

The digital image is 2D- array as:

I(0,0) I(0,1) ………………………..I(0,N-1)

I(1,0) I(1,1) ………………………..I(1,N-1)

…………………………………………………

……………………………………………………….

I(N-1,0) I(N-1,1) …….……………..I(N-1,N-1)

In above image matrix, the image size is (N×N) [matrix dimension] then:

Ng= 2 m ………..(1)

Where Ng denotes the number of gray levels m, where m is the no. of bits contains in digital image matrix.

Example :If we have (6 bit) in 128 X 128 image .Find the no. of gray levels to represent it ,then find the no. of bit in this image?

Solution:

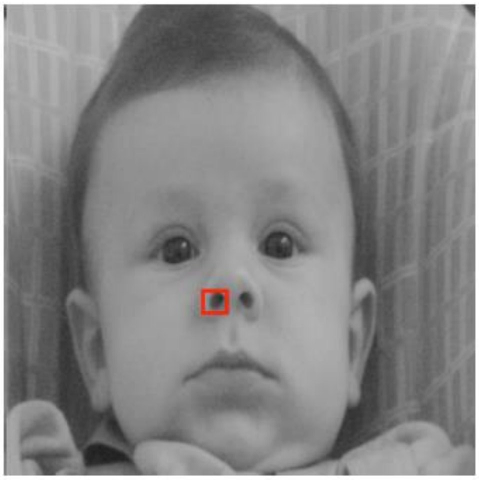
$Ng= 2^6=64$ Gray Level

Nb= 128 * 128* 6= 9.8304 * 104 bit

1-8 Image Resolution

In computers, resolution is the number of pixels (individual points of color) contained on a display monitor, expressed in terms of the number of pixels on the horizontal axis and the number on the vertical axis. The sharpness of the image on a display depends on the resolution and the size of the monitor. The same pixel resolution will be sharper on a smaller monitor and gradually lose sharpness on larger monitors because the same numbers of pixels are being spread out over a larger number of inches.

Still pictures which (uncompressed) are represented as a bitmap (a grid of pixels). Pixels are the building blocks of every digital image. Clearly defined squares of light and color data are stacked up next to one another both horizontally and vertically. Each picture element (pixel for short) has a dark to light value from 0 (solid black) to 255 (pure white). (Figure 1.9)



99	71	61	51	49	40	35	53	86	99
93	74	53	56	48	46	48	72	85	102
101	69	57	53	54	52	64	82	88	101
107	82	64	63	59	60	81	90	93	100
114	93	76	69	72	85	94	99	95	99
117	108	94	92	97	101	100	108	105	99
116	114	109	106	105	108	108	102	107	110
115	113	109	114	111	111	113	108	111	115
110	113	111	109	106	108	110	115	120	122
103	107	106	108	109	114	120	124	124	132

Figure 1.9: Represent each pixel part of Image by digits Between (0-255).

The Image as a input it's scanned for photographs or pictures using a digital scanner or from a digital camera and May also be generated by programs similar to graphics or animation programs, Analog sources will require digitizing.

A display with 240 pixel columns and 320 pixel rows would generally be said to have a resolution of 240×320. Resolution can also be used to refer to the total number of pixels in a digital camera image. For example, a camera that can create images of 1600x1200 pixels will sometimes be referred to as a 2 megapixel resolution camera since 1600 x 1200 = 1,920,000 pixels, or roughly 2 million pixels. Where a megapixel (that is, a million pixels) is a unit of image sensing capacity in a digital camera. In general, the more megapixels in a camera, the better the resolution when printing an image in a given size.

There are three types of resolution measuring different aspects of the quality, detail and size of an image:

- Color resolution
- Image resolution
- Display resolution

- Color Resolution / Color Depth: Color depth describe the number of bits used to represent the color of a single pixel.

- Image Resolution: The term resolution often associated with an image's degree of detail or quality.
- Display Resolution: Resolution also can refer to quality capability of graphic output (monitor).

1-9 Image Representation

The digital image I (r, c) is represented as a two- dimensional array of data, where each pixel value corresponds to the brightness of the image at the point (r, c). in linear algebra terms , a two-dimensional array like our image model I(r, c) is referred to as a matrix , and one row (or column) is called a vector. The image types we will consider are:

1-9-1 Binary Image

These images have two possible values of pixel intensities: black and white.

Also called 1-bit monochrome image, since it contains only black and white.

Typical applications of binary images include office/business documents, handwritten text, line graphics, engineering graphics etc.

The scanned output contains a sequence of black or white pixels. Binary 0 represents a black pixel and binary 1 represents a white pixel.(Figure 1.10)

Figure 1.10: Example of Binary Image.

1-9-2 Grayscale Image

They contain several shades of grey. The number of different brightness level available. (0) value refers to black color, (255) value refers to white color, and all intermediate values are different shades of gray varying from black to white.

Typical applications of grayscale images include newspaper photographs (non-color), magnetic resonance images and cat-scans.

An uncompressed grayscale image can be represented by n bits per pixel, so the number of gray levels supported will be 2^n.

For example, 8-bit Grayscale Image. It consists of 256 gray levels. A dark pixel might have a pixel value of 0, a bright one might be 255. (Figure 1.11)

Figure 1.11: Example of Grayscale Image.

1-9-3 Color Image

They are characterized by the intensity of three primary colors (RGB).The actual information stored in the digital image data is brightness information in each spectral band. When the image is displayed, the corresponding brightness information is displayed on the screen by picture elements that emit light energy corresponding to that particular color.

For example, 24-bit image or 24 bits per pixel. There are 16,777,216 (224) possible colors. In other words, 8 bits for R(Red), 8 bits for G(Green), 8 bits for

B(Blue). Since each value is in the range 0-255, this format supports 256 x 256 x 256 or 16,777,216 different colors. (Figure 1.12 & 1.13)

Figure 1.12: Example of color Image.

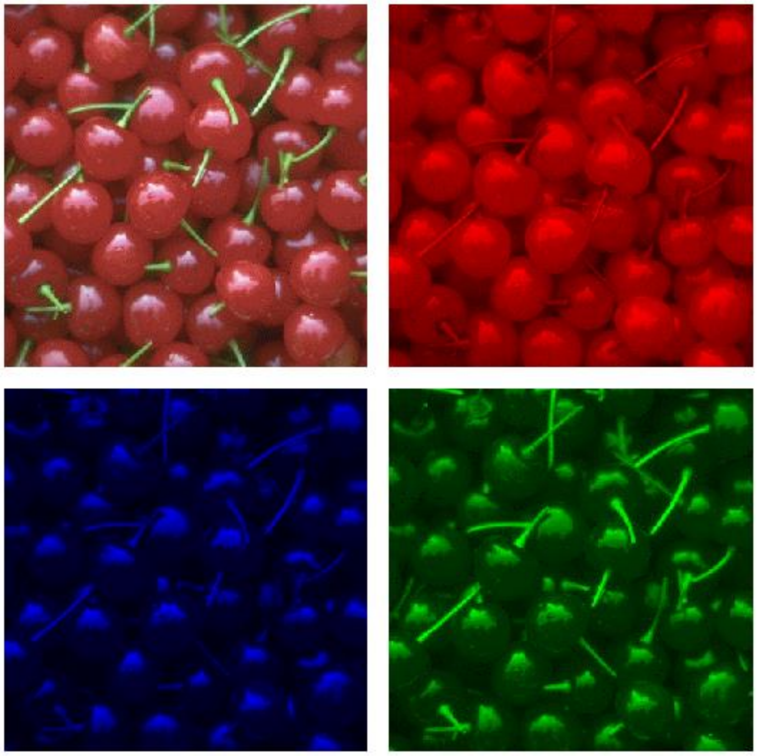


Figure 1.13:Typical RGB color image can be thought as three separate images

For many applications, RGB color information is transformed into mathematical space that decouples the brightness information from the color information.

The hue/saturation /lightness (HSL) color transform allows us to describe colors in terms that we can more readily understand.

The lightness is the brightness of the color, and the hue is what we normally think of as “color” and the hue (ex: green, blue, red, and orange). The saturation is a measure of how much white is in the color (ex: Pink is red with more white, so it is less saturated than a pure red).

An important point: many 24-bit color images are actually stored as 32-bit images, with the extra byte of data for each. These are Called RGBA / 32-bit images.

Allows RGBA color scheme; Red, Green, Blue, Alpha.

8Pixel used to store an alpha value representing the degree of “transparency”.

1-9-4 Multispectral Images

A multispectral image is one that captures image data within specific wavelength ranges across the electromagnetic spectrum. The wavelengths may be separated by filters or by the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range, i.e. infrared and ultra-violet. Spectral imaging can allow extraction of additional information the human eye fails to capture with its receptors for red, green and blue. It was originally developed for space-based imaging.(Figure 1.14)

Figure 1.14: Example of multispectral Image.

1-10 Computer Graphics

There are two kinds of computer graphics depend on types of Image data:

1. Bitmap image (or raster image): can represented by the image model I(r, c). Bitmap is a simple matrix of the tiny dots called pixel that forms a raster or bitmap image. Each pixel data is corresponding to brightness value stored in file format.
2. Vector images: refer to the methods of representing lines, curves shapes by storing only the key points. These key points are sufficient to define the shapes, and the process of Turing theses into an image is called rending after the image has been rendered, it can be thought of as being in bit map format where each pixel has specific values associated with it.

1-11 Bitmap-file Structure

The bitmap file structure is very simple and consists of a bitmap-file header, a bitmap-information header, a colour table, and an array of bytes that define the bitmap image. The file has the following form:

File Header Information
Image Header Information
Colour Table (if present)

The bitmap file header contains information about the type, size, and layout of a bitmap file and permits a check as to the type of file the user is reading.

The bitmap-information header specifies the dimensions, compression type, and colour format for the bitmap.

The final entries in the bitmap information section are the number of color map entries and the number of significant colors.

Additionally, with some of the more complex file formats, the header may contain information about the type of compression used and other necessary parameters to create the image, I(r,c).

1-12Image File Format

Image file formats are standardized means of organizing and storing digital images. Image files are composed of digital data in one of these formats that can be rasterized for use on a computer display or printer. An image file format may store data in uncompressed, compressed, or vector formats. Once rasterized, an image becomes a grid of pixels, each of which has a number of bits to designate its color equal to the color depth of the device displaying it.

Here are some of the most important types of image file formats

1-12-1BMP file format:

Windows bitmap handles graphic files within the Microsoft Windows OS. Typically, BMP files are uncompressed, and therefore large and lossless; their advantage is their simple structure and wide acceptance in Windows programs.

1-12-2GIF file format:

(Graphic Interchange Format) is an uncompressed file format that supports only 256 distinct colors. Best used with web clip art and logo type images. GIF is not suitable for photographs because of its limited color support

1-12-3PNG file format:

The PNG (Portable Network Graphics) file format was created as a free, open-source alternative to GIF. The PNG file format supports eight-bit paletted images (with optional transparency for all palette colors) and 24-bit truecolor (16 million colors) or 48-bit truecolor with and without alpha channel - while GIF supports only 256 colors and a single transparent color.

PNG is designed to work well in online viewing applications like web browsers and can be fully streamed with a progressive display option. PNG is robust, providing both full file integrity checking and simple detection of common transmission errors.

1-12-4JPEG file format:

Joint Photographic Expert Group is a compressed file format that supports 24 bit color (millions of colors). This is the best format for photographs to be shown on the web or as email attachments. This is because the color informational bits in the computer file are compressed (reduced) and download times are minimized.

1-12-5TIFF file format:

Format Tag Image File is an uncompressed file format with 24 or 48 bit color support. Uncompressed means that all of the color information from your scanner or digital camera for each individual pixel is preserved when you save as TIFF. TIFF is the best format for saving digital images that you will want to print. Tiff supports embedded file information, including exact color space.