Note of DIP

1 Chapter 1

1.1 Digital image

digital image : x,y and the intensity of f are all *finite,discrete quantities*.

1.2 Computerized processing:

Low-level : input is image,output is image.

Mid-level : input is image,output is attributes on image.

Higher-level : "making sense"of ensemble of recognized objects,and performing the cognitive functions.

2 Chapter 2

2.1 Elements of Visual Perception

1. weber ratio : $\Delta I_c / I$

   I : light source intensity

   $\Delta I_c := \frac{1}{2} \Delta I$

   ΔI : an increasement of illumination

2. Mach bands : the undershoot and overshoot of bundaries.

   Simultaneous contrast : a region's perceived brightness does not depend simply on its intensity.

2.2 Light and the Electromagnetic Spectrum

1. Wave length (λ) & Frenquency (v) :

$$\lambda = \frac{c}{v}$$

c : the speed of light. (2.998×10^8 m/s)

E : energy & h : planck's constant

$$E = hv$$

2. Basic qualities of light source

a. frenquency

b. radiance (w) : total amount of energy that flows from the light source.(measured in watts)

c. luminance (lm) : measured in lumens, a measure of the amount of energy that flows from the light source.

d. brightness : a subjective descriptor of light perception that is particular impossible to measure.

2.3 Image Sensing and Acquisition

1. Three principal sensor arrangements of image acquisition

a. Single imaging sensor : the most familiar is the photodiode,which is constructed of silicon materials and whose output voltage waveform is proportional to light.

b. Line sensor a geometry consists of an in-line arrangement of sensors in the form of a sensor strip is used much frequently.Sensor strips mounted in a ring configuration are used in medical and industrial imaging.

c. Array sensor : Numerous electromagnetic and some ultrasonic sensinig devices frequently are arranged in an array format.This is also the predominant arrangement found in digital cameras.

Key advantage : a complete image can be obtained by focusing the energy pattern onto the surface of the array.

2.$f(x,y) = i(x,y)r(x,y)$

illumination : $i(x,y)$ *reflectance :* $r(x,y)$

$$0 < i(x,y) < \infty \tag{1}$$

$$0 < r(x,y) < 1 \tag{2}$$

0 : total absorption 1 : tatal reflectance

The nature of $i(x,y)$ is determined by the **illumination source** and $r(x,y)$ is determined by the **characteristics of the imaged objects**.

**we would deal with a *transmissivity* instead of a *reflectivity* functions when these expressions applied to images formed via transmission of the illumination through a medium.

2.4 Image Sampling and Quantization

(convert the continuous sensed data into digital form)

1. Basic Concepts a. *sampling* : digitizing the coordinate values

b. *quantization* : digitizing the amplitude values

2. Representing Digital Images

a. $f(x,y)$: the value of the image at any coordinates (x,y). x,y are integers.

b. *spatial domain* : the section of the real plane spanned by the coordinates of an image. and x,y are referred to as spatial *variables* or *spatial coordinates*.

3. three basic ways to represent $f(x,y)$:

a. *(x,y,z)*,x and *y* are spatial coordinates and *z* is the value of *f* at coordinates *(x,y)*

b. *f(x,y)*is shows,and the intensity of each point is proportional to the value of *f* at that point. allow us to **view results at a glance**

c. simply display the numerical values of *f(x,y)* as an array (matrix). allow us are used for **processing and algorithm development**. Each element of matrix is called an *image element,picture element,pixel or pel.*

It's advantageous to use a more traditional matrix notation to denote a digital image and its elements;

$$\begin{pmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,N-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,N-1} \\ \vdots & \vdots & & \vdots \\ a_{M,0} & a_{M,1} & \cdots & a_{M,N-1} \end{pmatrix}$$

**NOTE : the origin of a digital image is at the top left,with the positive $x-axis$ extending downward and the positive $y-axis$ extending to the right.

4. *discrete intensity levels (L)* : typically is an integer power of 2

$$L = 2^k$$

We difine the *dynamic range* of an imaging system to be the ratio of the *maximum measurable intensity* to the *minimum detectable intensity* levle in the system. As a rule,the upper limit is determined by *saturation* and the lower limit by *noise*

contrast : the difference in intensity between the highest and lowest intensity levels in an image. A higher dynamic range an image have,a higher contrast.

b : bits required to store a digitized image

$$b = M \times N \times k$$

When M = N ,this equation becomes x

$$b = N^2 k$$

5. *spatial resolution* : common measures with $line\ pairs\ per\ unit\ distance,\ and\ dots\ (pixels)\ per\ unit\ distance.$

image resolution the largest number of *discernible* line pairs [er unit distance.

intensity resolution : similarly refers to the smallest discernible change in intensity level.

It was found that the isopreference curves tended to shift right and upward.Because a shift up and right in the curves simply means larger values for N and k, which implies beeter picture quality.

6. Image Interpolation : the process of using known data to estimate values at unknown locations.

a. *nearest neighbor interpolation* : assigns to each new location the intensity of its nearest neighbor in the original image.

b. *bilinear interpolation* : the assigned value is obtained using the equation:

$$v(x, y) = ax + by + cxy + d$$

where the four coefficients are determined from the four equations in four unknowns that can be written using the four nearest neighbors of point(x,y).

c. *bicubic interpolation* : involves the sixteen nearest neighbors of a point.The intensity value assigned to point(x,y)is obtained using the equation

$$v(x, y) = \sum_{i=0}^{3} \sum_{j=0}^{3} a_{ij} x^i y^i$$

2.5 Basic Relation between Pixels

1. V : the set of intensity values used to define adjacency. S : represent a subset of pixels in an image.

R : a subset of pixels in an image. We call R a region of the image if R is connected set.Two regions,R_i *and* R_j are said to be adjacent if their union forms a connected set.

2. distance measures D is a distance funtion or metric if

$$D(p, q) \geq 0 \ (D(p, q) = 0 \ iff \ p = q)$$

$$D(p, q) = D(q, p)$$

$$D(p, z) \leq D(p, q) + D(q, z)$$

the Euclidean distance between p and q is defined as

$$D_e(p, q) = [(x - s)^2 + (y - t)^2]^{\frac{1}{2}}$$

The D_4 distance (called the city-block distance) between p and q is defined as

$$D_4(p,q) = |x-s| + |y-t|$$

$$\begin{array}{ccccc} & & 2 & & \\ & 2 & 1 & 2 & \\ 2 & 1 & 0 & 1 & 2 \\ & 2 & 1 & 2 & \\ & & 2 & & \end{array}$$

The D_8 distance (called the chessboard distance)between p and q is defined as

$$D_8(p,q) = max(|x-s|, |y-t|)$$

$$\begin{array}{ccccc} 2 & 2 & 2 & 2 & 2 \\ 2 & 1 & 1 & 1 & 2 \\ 2 & 1 & 0 & 1 & 2 \\ 2 & 1 & 1 & 1 & 2 \\ 2 & 2 & 2 & 2 & 2 \end{array}$$

2.6 Mathematical Tools

1. Linear operaor : H

$$\begin{aligned} H[a_i f_i(x,y) + a_j f_j(x,y)] &= a_i H[f_i(x,y)] + a_j H[f_j(x,y)] \\ &= a_i g_i(x,y) + a_j g_j(x,y) \end{aligned}$$

2. Four arithmetic operations are doneted as

$$s(x,y) = f(x,y) + g(x,y)$$

$$d(x,y) = f(x,y) - g(x,y)$$

$$p(x,y) = f(x,y) \times g(x,y)$$

$$v(x,y) = f(x,y) \div g(x,y)$$

It is understood that the operations are performed between corresponding pixel pairs in f and g for x=0,1,2,...,M-1 and y=0,1,2,...,N-1.

3. Spatial Operations are performed directly on the pixels of a given image.We classify spatial operations into three broad categories : (1)single-pixel operations,(2)neighborhood operations,(3)geometric spatial transformations.

a. Single-pixel operations

$$s = T(z)$$

z is the intensity of a pixel in the original image and s is the (mapped)intensity of the corresponding pixel in the processed image.

b. Neighborhood operations : $g(x, y) = \frac{1}{mn} \sum_{(r,c) \in S_x y} f(r, c)$

c. Geometric spatial transformations modify the spatial relationship between pixels in an image.These transformations often are called *rubber-sheet* transformations because they may be viewed as analogous to "printing" an image on a sheet of rubber and then stretching the sheet according to a predefined set of rules.It consists of two basic operations:(1)a spatial transformation of coordinates and (2)intensity interpolation that assigns intensity values to the spatially transformed pixels.

The most commonly used spatial coordinate transformations is :

$$[x\ y\ 1] = [v\ w\ 1]\mathbf{T} = [v\ w\ 1] \begin{bmatrix} t_{11} & t_{12} & 0 \\ t_{21} & t_{22} & 0 \\ t_{31} & t_{32} & 1 \end{bmatrix}$$

4. 2-D linear transforms,denoted T(u,v),can be expressed in the general form

$$T(u, v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) r(x, y, u, v)$$

$f(x, y)$ is the input image,$r(x, y, u, v)$ is called the *forward transformation kernel*.