Digital Image Processing Report

Image Enhancement

ID： 13S058029

Name：曾伟浩

Digital Image Enhancement Experiment Report

1. Platform

This project is programed by C program language and implemented by VC2008 software in Windows 7.

2. Motivation

As we know, the image contrast is not obvious and the details are not clear to our eyes. Therefore, we have to do some image enhancement to stretch the range of pixels. As a result, many methods are implemented to improve the image contrast of this kind of images or photos. In this problem, there are the following five methods I implemented to improve the image contrast.

a. Histogram Equalization Method.

b. Linear Transformation Method.

c. Power Law Transformation Method.

d. Laplacian Image Enhancement Method.

e. Combining Spatial Enhancement Methods.

3. Implement

In this project, there are four methods and a combining spatial enhancement method are used for improving the image contrast. The project package contains five bmp images which is tested by five methods respectively.

3.1. What does this program do

Figure 3.1 shows the structure of the program. It contains three major C language source files and two header files. Bmp.cpp includes the image basic functions, like open and read a bmp image from disk, print the information of the image and display original and processed image. The imgEnhancement.cpp includes the some enhancement methods functions, which are histogram equalization, linear transformation, power law transformation, laplacian or sobel enhancement, add and multiply two images and smooth image methods. What I have done in main.cpp to call functions from the other two C source file, firstly, input the path of image you want to enhance, check if the path is legal and load and read the bmp, then implement the enhancement function to prove the image contrast, finally save processed image to your disk and display by your computer.

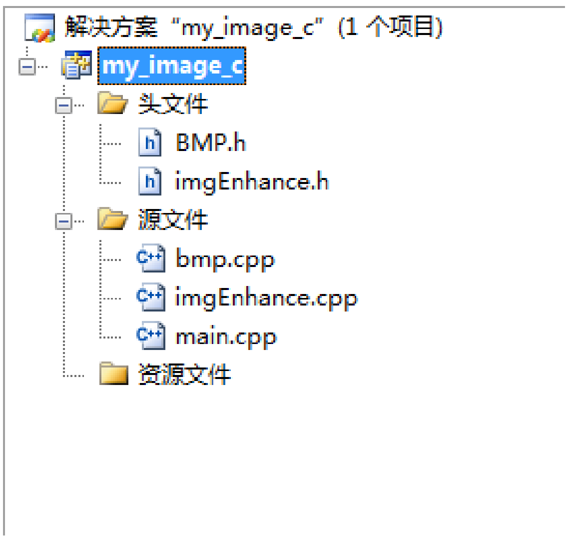

Figure 3.1 program structure

Figure 3.2 shows an example about how to use the software.

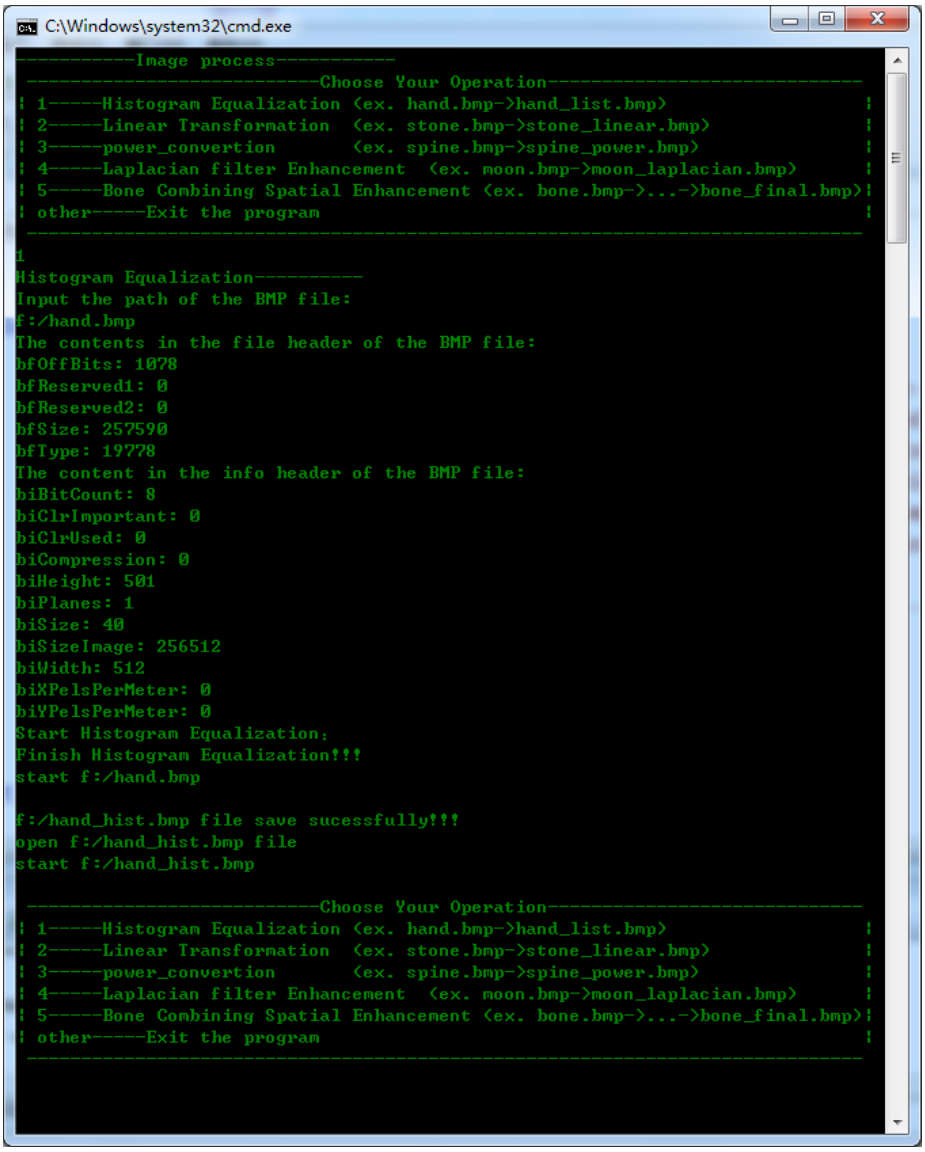

Figure 3.2 an example

3.2. Histogram Equalization Method

The concept of histogram equalization is making the histogram of the enhanced image be uniform. Histogram equalization, the input pixel intensity, x is transformed to new intensity value, x′ by T. The transform function, T is the product of a cumulative histogram and a scale factor. The scale factor is needed to fit the new intensity value within the range of the intensity values, for example, 0 ~ 255.

$$x' = T(x) = \sum_{i=0}^{x} n_i \cdot \frac{\text{max. intensity}}{\text{N}}$$

where n_i is the number of pixels at intensity i,

N is the total number of pixels in the image

3.2.1 Histogram Equalization Method Implement

The following image is an example of histogram equalization. Figure 3.3 is original hand bmp file and Figure 3.4 is processed image file.

Figure 3.3 original hand image

Figure 3.4 processed hand image

3.3. Linear Transform Method

One of the simplest piecewise linear functions is a contrast-stretching transformation. Low-contrast images can result from poor illumination, lack of dynamic range in the imaging sensor, or even wrong setting of a lens aperture during image acquisition. The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image being processed. If the original image f (x, y) of the gray level range of [a, b], and we want to transform the image g (x, y) gray range extends to [c, d], the following is the mathematical expressions for this method.

$$g(x, y) = [(d - c)/(b - a)] * f(x, y) + c$$

3.3.1 Linear Transform Method Implement

The following image is an example of linear transform. Figure 3.5 is original stone bmp file and Figure 3.6 is processed image file.

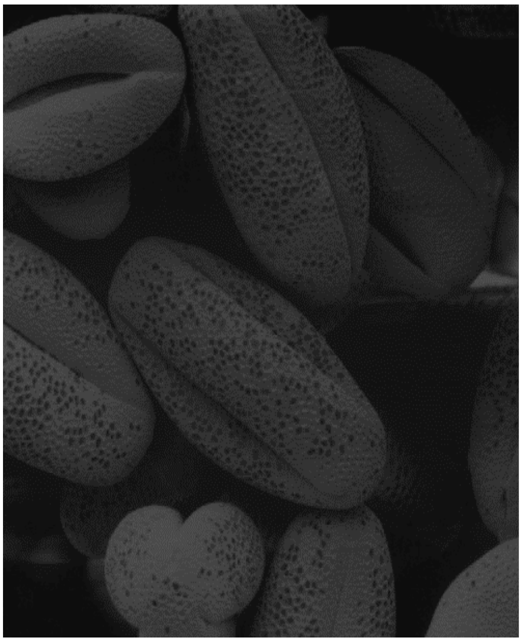

Figure 3.5 original stone image

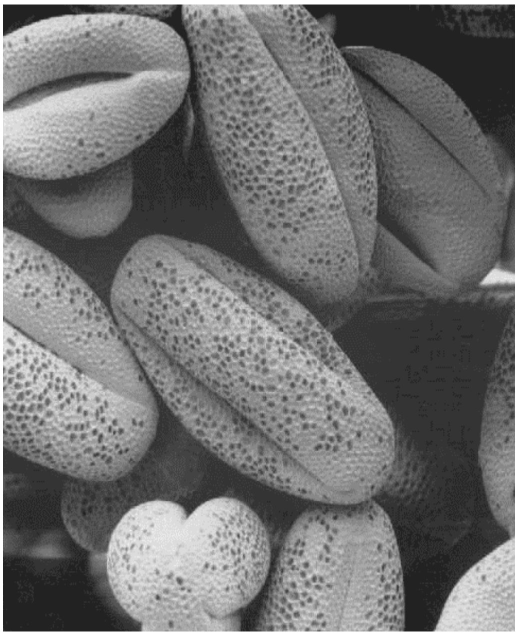

Figure 3.6 processed stone image

3.4. Power Law Transformation Method

Power-law transformations have the basic form

$$s = cr^{\gamma} \quad (3\text{-}1)$$

where c and γ are positive constants. Sometimes Eq. (3-1) is written as $s = c(r + \varepsilon)^{\gamma}$ to account for an offset (that is, a measurable output when the input is zero). However, offsets typically are an issue of display calibration and as a result they are normally ignored in Eq. (3-1). As in the case of the log transformation, power-law curves with fractional values of y map a narrow range of dark input values into a wider range of output values, with the opposite being true for higher.

3.4.1 Power Law Transformation Method Implement

The following image is an example of Power Law Transformation Method. Figure 3.7 is original spine bmp file and Figure 3.8 is processed image file.

Figure 3.7 original spine image

Figure 3.8 processed spine image

3.5. Laplacian Image Enhancement Method.

It can be shown (Rosenfeld and Kak [1982]) that the simplest isotropic derivative operator is the Laplacian, which, for a function (image) f(x, y) of two variables, is defined as

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad (3\text{-}2)$$

Because derivatives of any order are linear operations, the Laplacian is a linear operator. The digital implementation of the two-dimensional Laplacian in Eq. (3-2) is obtained by summing these two components:

$$\nabla^2 f = [f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1)] - 4f(x,y)$$

3.5.1 Laplacian Image Enhancement Method Implement

The following image is an example of Laplacian Method. Figure 3.9 is original spine bmp file and Figure 3.10 is processed image file.

Figure 3.9 original moon image

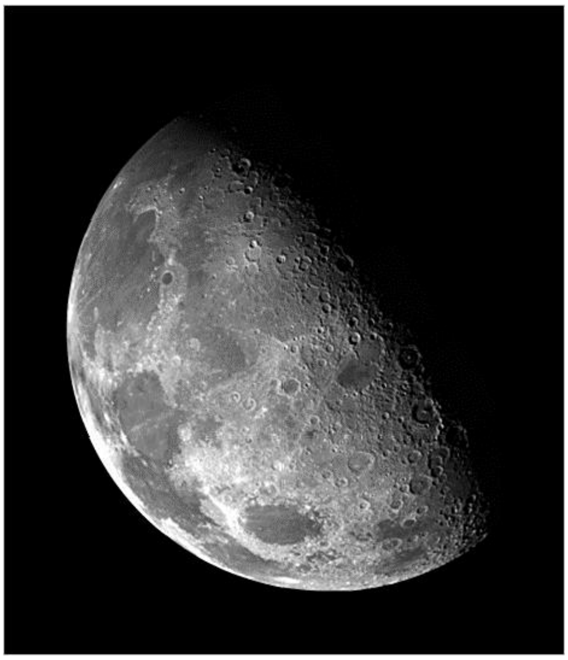

Figure 3.10 processed moon image

3.6. Combining Spatial Enhancement Methods.

Frequently, a given enhancement task will require application of several complementary enhancement techniques in order to achieve an acceptable result. In this chapter we illustrate by means of an example how to combine several of the approaches developed in this chapter to address a difficult enhancement task. The image shown in Fig. 3.11(a) is a nuclear whole body bone scan. Our objective is to enhance this image by sharpening it and by bringing out more of the skeletal detail. The narrow dynamic range of the gray levels and high noise content make this image difficult to enhance. The strategy we will follow is to utilize the Laplacian to highlight fine detail, and the gradient to enhance prominent edges. For reasons that will be explained shortly, a smoothed version of the gradient image will be used to mask the Laplacian image. Finally, we will attempt to increase the dynamic range of the gray levels by using a gray-level. An alternate approach is to use a mask formed from a smoothed version of the gradient of the original image. The motivation behind this is straightforward and is based on the properties of first-order and second-order derivatives explained in Eq. (3-2).

The Laplacian, being a second-order derivative operator, has the definite advantage that it is superior in enhancing fine detail. However, this causes it to produce noisier results than the gradient. This noise is most objectionable in smooth areas, where it tends to be more visible. The gradient has a stronger response in areas of significant gray-level transitions (gray-level ramps and steps) than does the Laplacian. The response of the gradient to noise and fine detail is lower than the Laplacian's and can be lowered further by smoothing the gradient with an averaging filter. The idea, then, is to smooth the gradient and multiply it by the Laplacian image. In this context, we may view the smoothed gradient as a mask image. The product will preserve details in the strong areas while reducing noise in the relatively flat areas. This process can be viewed roughly as combining the best features of the Laplacian and the gradient. The result is added to the original to obtain a final sharpened image, and could even be used in boost filtering.

Figure 3.11(c) shows the Sobel gradient of the original image. Edges are much more dominant in this image than in the Laplacian image. The smoothed gradient image shown in Fig. 3.11(d) was obtained by using an averaging filter of size 5*5. The two gradient images were scaled for display in the same manner as the two Laplacian images. Because the smallest possible value of a gradient image is 0, the background is black in the scaled gradient images, rather than gray as in the scaled Laplacian. The fact that Figs. 3.11(c) and (d) are much brighter than Fig. 3.11(a) is again evidence that the gradient of an image with significant edge content has values that are higher in general than in a Laplacian image. The product of the Laplacian and smoothed-gradient image is shown in Fig. 3.11(e). Note the dominance of the strong edges and the relative lack of visible noise, which is the key objective behind masking the Laplacian with a smoothed gradient image.

Adding the product image to the original resulted in the sharpened image shown in Fig. 3.11(f). The significant increase in sharpness of detail in this image over the original is evident in most parts of the image, including the ribs, spinal chord, pelvis, and skull. This type of improvement would not have been possible by using the Laplacian or gradient alone. The sharpening procedure just discussed does not affect in an appreciable way the dynamic range of the gray levels in an image. Thus, the final step in our enhancement task is to increase the dynamic range of the sharpened image. Since we wish to spread the gray levels, the value of y in Eq. (3-1) has to be less than 1. After a few trials with this equation we arrived at the result shown in Fig. 3.11 (g), obtained with $y = 0.5$ and $c = 1$. Comparing this image with Fig. 3.11(f), we see that significant new detail is visible in Fig. 3.11(g).The areas around the wrists, hands, ankles, and feet are good examples of this. The skeletal bone structure also is much more pronounced, including the arm and leg bones. Note also the faint definition of the outline of the body, and of body tissue. Bringing out detail of this nature by expanding the dynamic range of the gray levels also enhanced noise, but Fig. 3.11(g) represents a significant visual improvement over the original image.

3.5.1 Combining Spatial Enhancement Methods Implement

The following image is an example of Combining Spatial Enhancement Methods.

Figure 3.11(a) original bone image

Figure 3.11(b) laplacian and sharpened image

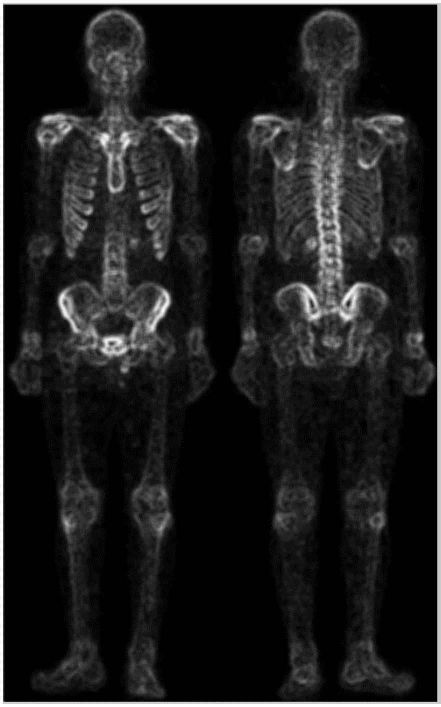

Figure 3.11(c) sobel of (a)

Figure 3.11(d) 5*5 smooth of (c)

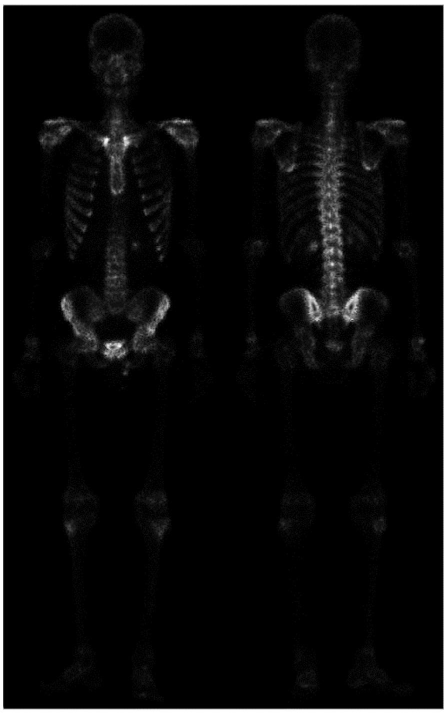

Figure 3.11(e) product of (b) and (d)

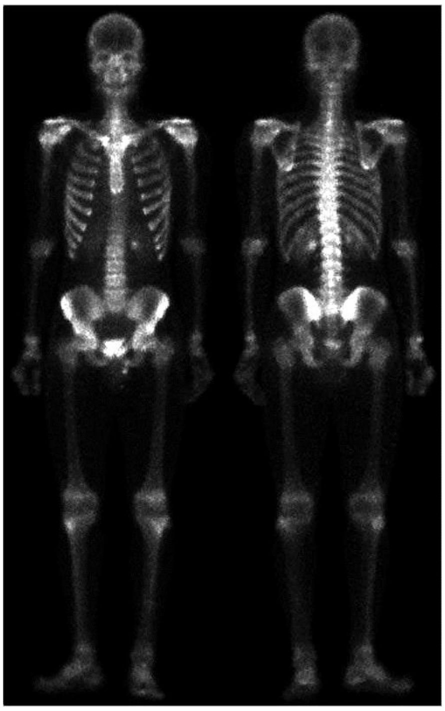

Figure 3.11(f) add of (a) and (e)

Figure 3.11(g) power law of (f)