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Design of medical image enhancement algorithm based on Python

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***Abstract*—The accuracy of medical diagnosis depends on the accuracy of image recognition, so the details of the pre-processing of medical images are more stringent, especially the edges of images that contain a lot of information need to be enhanced. Therefore, this article chooses to combine various enhancement methods in the spatial domain and apply python software to medical image enhancement. The experimental results show that the algorithm not only effectively retains the texture and details in the medical image, but also enhances the contour and edge of the medical image, so that some details that cannot be observed by the naked eye appear. At the same time, the use of python makes the whole algorithm more realized. Fast and more conducive to medical staff to observe the focus of the medical image.**

Keywords—medical image, image enhancement, Python, Roberts operator, Canny operator

I. INTRODUCTION

In recent years, with the advancement of science and technology, medical image processing has developed rapidly in the field of medical technology. Especially with the emergence of X-ray and MRI technologies, the clinical role of medical image processing has become increasingly important. In the current medical imaging consultation process, most of them rely on the doctor to observe a set of two-dimensional images taken by the medical machine to make judgments. Usually doctors interpret images from the doctor's subjective point of view, and there are huge differences in cognition and work fatigue. So, it can be seen that this method is not only subject to the doctor's own experience level, but also the image quality requirements. The accuracy of medical diagnosis depends on the accuracy of image recognition, so the details of the pre-processing of medical images are more stringent.

Due to the influence of light intensity, noise and other environmental factors in the imaging process of the target image, optical distortion occurs, which makes the brightness of the image dim and the edge blurred. As an important part of image processing, image enhancement is mainly to improve the intelligibility of images. For users, intelligibility is to enhance the region of interest in the image, while weakening the useless area of the image, which greatly improves the use value of the image.

II. SPATIAL DOMAIN ENHANCEMENT

A. Gray scale transformation

Among the various methods of image point operation, gray transformation is a more convenient one. The use of gray-scale transformation is one of the methods of point operation in image processing, and the operation method is simple and easy to understand. Only the operation of the pixel means that the gray transformation is only related to the gray value of the pixel. Linear and non-linear transformation are the two most commonly used methods of gray-scale transformation.

Suppose that the gray range of an image named f is $[a,b]$, and the gray range of the image named g after linear transformation is $[a',b']$, as shown in Figure 1, then the relationship between gray level f and gray level g is

$$g = a' + \frac{b'-a'}{b-a}(f-a)$$

According to the above formula, when $b'-a' > b-a$, the gray range of the original image can be expanded, and the overall brightness, contrast and clarity of the image can be improved.

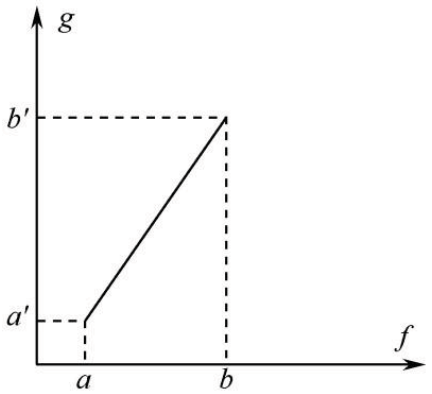

Fig. 1. Linear Transformation

B. Roberts gradient operator

The function $f(x,y)$ gradient is defined as

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

Among them, Roberts edge detection operator, which is

the earliest used, is often used by researchers because of its simple template. It is worth noting that the core of this method is to use the local difference method, and the direction is chosen to be perpendicular to each other. In short, the operator uses the following formula to calculate the gray difference of adjacent pixels as the approximate value of gradient.

$$|\nabla f(i,j)| \approx |f(i+1,j+1)-f(i,j)| + |f(i+1,j)-f(i,j+1)|$$

The template used is as follows:

$$G_x = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

$$G_y = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}$$

Roberts operator is often used to deal with images with steep noise. However, because it has no effect on the local noise in the image, the edge detected by this method will appear discontinuity.

C. Canny operator

The gradient of Canny detection operator is calculated by the reciprocal of Gaussian filter, and the edge appears at the local maximum of gradient. Canny's main work is to derive the optimal edge detection operator, which can suppress false edges and is not easily disturbed by noise. The calculation steps are as follows:

Gaussian function is used to smooth the image. Let the Gauss function be:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{x^2+y^2}{2\sigma^2}}$$

Two dimensional convolution $\nabla G(x,y) * f(x,y)$ is calculated to smooth the image;

The edge intensity and direction after filtering are calculated, and the edge is detected by threshold. The two-dimensional convolution template $\nabla G(x,y)$ is decomposed into a one-dimensional filter.

$$\frac{\partial G(x,y)}{\partial x} = kxe^{-\frac{x^2}{2\sigma^2}} e^{-\frac{y^2}{2\sigma^2}} = h_1(x)h_2(y)$$

$$\frac{\partial G(x,y)}{\partial y} = kye^{-\frac{x^2}{2\sigma^2}} e^{-\frac{y^2}{2\sigma^2}} = h_1(y)h_2(x)$$

In the formula:

$$h_1(x) = \sqrt{k}xe^{-\frac{x^2}{2\sigma^2}}$$

$$h_1(y) = \sqrt{k}ye^{-\frac{y^2}{2\sigma^2}}$$

$$h_2(x) = \sqrt{k}e^{-\frac{x^2}{2\sigma^2}}$$

$$h_2(y) = \sqrt{k}e^{-\frac{y^2}{2\sigma^2}}$$

And then the two templates are convoluted with $f(x,y)$ respectively;

$$A = \sqrt{E_x^2 + E_y^2}$$

$$a = \arctan\left[\frac{E_y(x,y)}{E_x(x,y)}\right]$$

$$E_x = \frac{\partial G(x,y)}{\partial x} * f$$

$$E_y = \frac{\partial G(x,y)}{\partial y} * f$$

The conditions for judging whether a pixel is an edge are as follows: the edge intensity of a pixel is greater than that of two adjacent pixels along the gradient direction; the direction difference between the edge intensity and the adjacent two points in the gradient direction of the pixel is less than 45 degrees; the maximum edge intensity in the 3×3 neighborhood centered on the pixel is less than a certain threshold value.

III. THE ALGORITHM IN THIS PAPER

Based on the description in the previous section, the flow chart of the algorithm in this paper is shown in Fig. 2

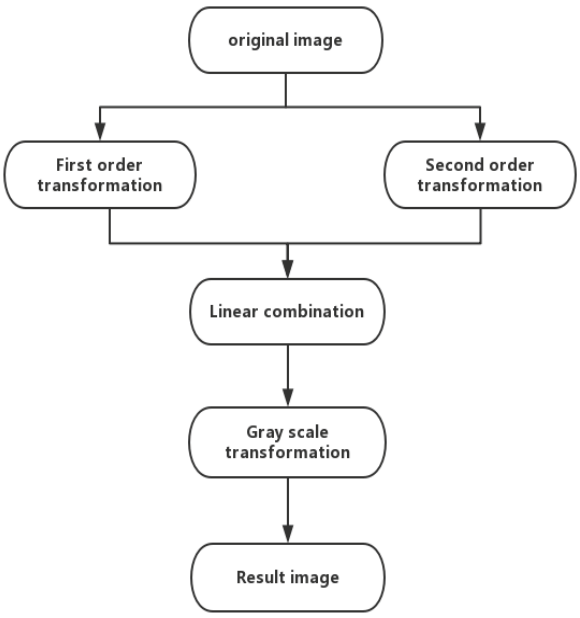

Fig. 2. Flow chart of the algorithm in this paper

- According to the above formula, two corresponding edges of the image are obtained;
- The images were combined linearly;
- Finally, the final image is obtained by gray transformation to a certain extent.

IV. Introduction to Python

According to the information from GitHub, a well-known code hosting platform, python has become one of the three major programming languages in the world. Many characteristics of Python language make it become one of the most popular languages in the world.

Python language is an interpretative high-level programming language. Python has a very powerful standard library. At the same time, the python community also provides a large number of third-party modules.

Python is an open source high-level computer programming language, which is used in computer vision, cloud computing, artificial intelligence and other fields.

Python comes with many powerful and convenient image processing toolkits, such as image processing toolkit (PIL), Matplotlib class library, numpy toolkit, etc. PIL provides free general image processing algorithms, as well as a large number of useful basic image operations, such as image scaling, rotation, clipping, changing image size, format and color conversion, image enhancement, interpolation and filtering. Matplotlib is a python 2D drawing library, which has powerful functions of drawing charts, points and lines, such as generating charts or histograms, power spectrum, and drawing points, lines and curves on images. Numpy is a python scientific computing toolkit, which can be used to store and process large matrices. It can realize the functions of matrix transposition, product, vector product, equation solving system and normalization. It provides the basis for modeling, image classification, image clustering and image deformation.

In addition, Opencv comes with a large number of algorithms and functions, and provides a perfect Python interface for easy call. It provides some image processing functions that complement Python well.

Take some examples of code:

```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt


def grayHist(img):
    ....
img = cv.imread("img.jpg", 0)
out = 1.5 * img
out[out > 255] = 255


out = np.around(out)
out = out.astype(np.uint8)
cv.imshow("img", img)
cv.imshow("out", out)
cv.waitKey()
```

V. Experimental results and analysis

At present, the most commonly used medical image types are as follows: X-ray imaging (X-CT), nuclear magnetic resonance imaging (MRI), nuclear medicine imaging (NMI) and ultrasonic imaging (UI). Both of them are widely used. Using Python and opencv toolkit, four brain MRI images in BMP format were selected to verify algorithm.

In this experiment, 121 MRI images were taken for the head, and each image was in BMP format. The picture is 512 in width and 512 in height. The image enhancement method in this paper is used for the four selected images, and the specific analysis is as follows.

As can be seen from Fig. 3, the overall brightness of picture 1 is improved after the algorithm in this paper, and the image outline is more obvious. Gray level transformation makes the image brightness increase, Roberts gradient operator sharpens the image, Canny operator selects the appropriate threshold to make the image edge be extracted. To sum up, the spatial method is integrated to overcome the shortcomings of single method and take into account the advantages of each method, so that the outline of the ear position on both sides of the brain and the skull details inside the image are all displayed. In addition, due to the Canny operator, the image noise does not increase significantly after multiple enhancement.

It can be seen from Fig. 4 that the gray histogram of picture 2 is changed after gray transformation, and the brightness and contrast of the picture are improved. The edge of image 2 is enhanced by the first-order operator. It is worth mentioning that the details of the internal tissue below the head in picture 2 that can not be observed in the original image can be observed clearly after the algorithm in this paper. In this picture, we can also see how much the original details of the skull are lost due to the linear combination of various methods. This is also the point that the algorithm in this paper should pay attention to in the subsequent development.

As can be seen from Figure 5, picture 3 can maximize the advantages of this method after being processed by this algorithm. Because this image is more detailed and the area to be observed is more complex than the other pictures we selected. Through the method of this paper, the brightness of this picture is obviously increased, the outline of the skull is also obviously extracted, and the internal tissue details are clearer. The ear and inner tissue texture in the picture is easier to observe. The original picture appears to be completely the same gray value of pixels, through the method in this paper, we can also see the gray difference between pixels, which is more conducive to the observation of doctors.

According to Fig. 6, the enhancement effect of picture 4 is similar to that of picture 3. If image 4 is only sharpened by Roberts gradient operator, most of the edges of the original image can be extracted, and the details of the image can not be extracted, especially the texture of the internal organization. In the same way, if only through the two-step

degree operator, such as Laplacian operator, the image edge will become continuous. However, after the algorithm in this paper, the internal texture of image 4 is very clear, and the internal lines of skull can be seen, which is very beneficial for doctors to diagnose the patient's condition.

According to the results of the above four images, it can be seen that the algorithm in this paper can enhance the edge details of medical image and expand the gray range of medical image, improve the overall image brightness, and facilitate medical staff to better observe the focus in the medical image.

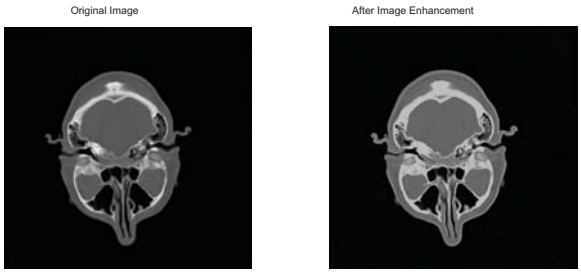

Fig. 3. Image 1 enhancement

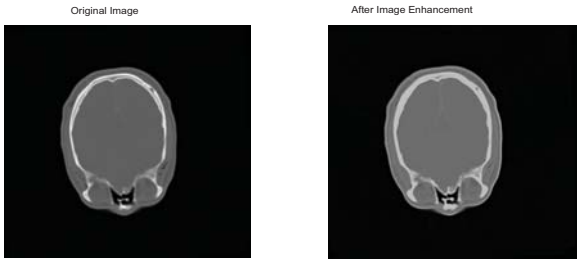

Fig. 4. Image 2 enhancement

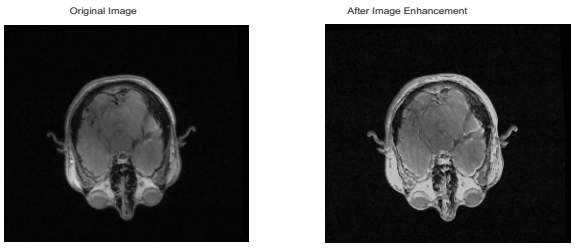

Fig. 5. Image 3 enhancement

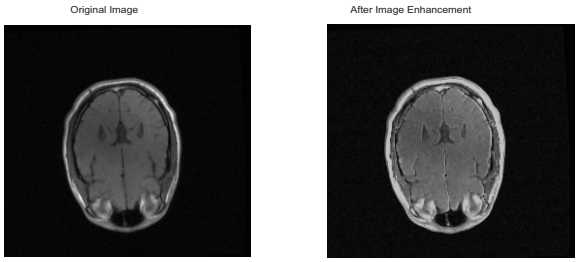

Fig. 6. Image 4 enhancement

VI. Conclusion

In this paper, a multi spatial filtering method based on Python is proposed. It extends the gray range of image by gray transformation, and enhances medical image by combining Roberts operator and Canny operator. This method makes full use of Python's powerful image processing function, realizes various image methods in spatial domain, eliminates the defects of single spatial image enhancement method, effectively retains the texture and details of medical image, and enhances the contour and edge of medical image.

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