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Research on Image Reduction of CT System

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Abstract: In order to obtain internal information of the medium than cannot be observed directly, we need to receive X-ray intensity data by CT system. However, the effect of data recovery is not ideal. In this paper, linear interpolation method is employed to eliminate metal artifact. After transforming the received information of template by Radon inversion, we get the geometry of unknown medium; the rotated position of observation points can be obtained by the point coordinate transformation model of the rectangular coordinate system, then the absorption rate of medium in 10 positions can be determined.
Keywords: CT system, linear interpolation method, Radon inversion, point coordinate transformation model

I. INTRODUCTION

Due to its non-contact, non-destructive, high resolution, no impact overlap, computed Tomography (CT), one of most advanced imaging techniques, is an indispensable and important technology, which has already been used in clinical medicine, industry, material and biology. CT is also a kind of noninvasive imaging technology[1-6]. It can obtain tomography images of biological tissue and engineering materials by absorption properties of sample to ray energy in the case of no destruction of the sample. Thus, we can get information of internal structure. Clear images allow people to analyze objects intuitively and concretely. Therefore, it is important to find a suitable method to recover clearer images based on X-ray data messages in CT investigation. In this paper, we studied a method to remove the noise from ray-received information and a method of image recovery of CT system.

II. BACKGROUND

According to the known data such as rotation center, detector spacing and rotation angle of CT system, the location, geometry and absorptivity of the unknown medium in the square pallet can be determined.

First of all, after the Radon Function transformation being used based on template location data, we can get a 362×362 pixel received information data of template, then transformed into an intuitive image. By using the known initial angle and the rotation center after the CT system migration, the position of the square tray in the image is determined, then the position of the unknown medium in the tray can be further confirmed.

After that, we transform template absorption data by Radon inversion and get the geometric shape of an unknown medium. The direct coordinate system Oxy is established based on the geometric center of the pallet, then the right angle coordinate system $O'x'y'$ is set at the origin of the rotation center. The position of the corresponding points is obtained through the point coordinate transformation formula of the rectangular coordinate system, so as to determine its absorptivity.

After observing images that is obtain by directly Radon inversion transforming [7-11] accepted information data of a template, it can be seen that the measured medium is unevenly distributed and the string graph in the original data is not smooth, which requires the preprocess of original data. Some of these values are interpolated to get the new observation data, and then the Radon conversion is carried out again.

III. PRELIMINARIES

1. CT number

According to the CT principle, the image reconstructed by CT should be the distribution of the attenuation coefficient μ , in a certain direction l ,and the total attenuation along a certain path L is $\int_L \mu dl = \ln(I_0 / I)$, I_0 is the intensity of ray emitted by X-ray source, I is the intensity of ray received by detector after attenuation.

After testing, the μ of water is $0.19cm^{-1}$. In the CT principle and algorithm, the definition of the number of CT is:

$$CT = \frac{\mu_t - \mu_w}{\mu_w} \times 1000$$

Where μ_t, μ_w are linear attenuation coefficients of the detected medium and water respectively. Thus, we can roughly determine the type of the substance based on the calculated values.

2. Data preprocessing

Providing that the coordinate of function $y = f(x)$ in the interval $[x_0, x_1]$ are $(x_0, f(x_0))$, $(x_1, f(x_1))$,the one element linear function $y = l_1(x) = ax + b$ approximately replaces function y ,and the appropriate parameters a , b are selected to meet:

$$l_1(x_0) = f(x_0), l_1(x_1) = f(x_1)$$

Then it can be said that the phenomenon function $l_1(x)$ is the linear interpolation function of y .

The simple function is used to fit the function equation, so as to achieve the simplified operation and get the calculation result after the complex formula.

The expression of the $l_1(x)$ that can be obtained by the two points formula of the linear equation is:

$$l_1(x) = \frac{x_1 - x}{x_1 - x_0} y_0 + \frac{x - x_0}{x_1 - x_0} y_1 \quad (1)$$

This is a simple linear interpolation basis function, and $l_1(x) = y_0 m_0(x) + y_1 m_1(x)$.

According the points mentioned above, we can see that linear interpolation is based on interpolating and fitting other points via two points of known function. Further, it does interpolate the data of the normal part in the string map of the CT image with metal artifacts to obtain accurate graphical edges.

The projection data θ under angle λ_θ is the interpolation function that we need to find. At this angle, the corresponding interpolation interval $[x_0, x_1]$ can be found in the interval of the artifact data (q_θ, p_θ), while a certain coordinate α under the θ angle corresponds to the interpolation point x . Thus, when linear interpolation is used to eliminate metal artifacts, the (1) formula can be converted to (2):

$$g_\theta(\alpha) = \frac{q_\theta - \alpha}{q_\theta - p_\theta} g_\theta(p_\theta) + \frac{\alpha - q_\theta}{q_\theta - p_\theta} g_\theta(q_\theta) \quad (2)$$

Therefore there vise d projection information $g_\theta(\alpha)$ can be obtained.

IV. ESTABLISHMENT AND SOLUTION OF THE MODEL

1. Determination the geometry of the unknown medium

The new data is converted by Radon conversion to obtain the restored image under the interpolation function.

The Matlab operation is used to get the Radon restore image before and after the received data process:

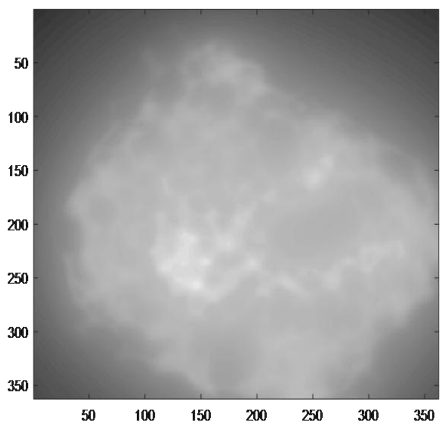

Fig. 1 :The restored image before Radon process

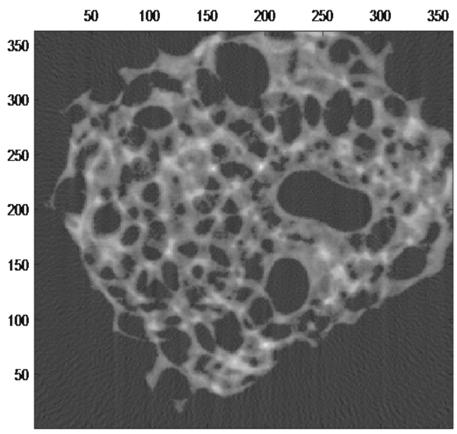

Fig. 2:The restored image after Radon process

Compared with two images, it can be found that the resolution of the handled image after Radon recovery is obviously improved. When the standard installed CT system works, the parallel light source beam always covers the pallet to ensure the full entry of media information on the pallet. When the launcher revolves around the rotating center, the entered data is enough to describe all the media on the pallet. The restore image after *Radon* process of received data is showed in Fig. 2. with a border length greater than $\sqrt{2c}$ at least (c is the length of the pallet). The 512 detectors in the title is about 141.26mm wide and can fully describe any medium on a square tray with a border length of 100mm. At this moment, the image that has been restored through the data isan image with a pixel greater than 256, and the image is restored to 362×362 pixels by Radon.

2. Determination the position of the tray

The location of the measured medium on the pallet is fixed, which means that no matter how the center of rotation is deflected, the position of the pallet determined by the offset parameter of the rotation center is stable on the restored image. The deviation between the image reduced by Annex 2 and the actual direction of the object on the tray is the initial detection angle θ of the detector. The angle deviation of the image reduction is closely related to the initial position of the detector, and the parallel deviation length is the distance between the center of the tray geometry and the rotation center of the CT system. Thus, the specific location of the tray can be determined.

In this question, the Radon restored image cannot fully contain the pallet area due to the offset of the rotation center. In another word, there are parts of the tray plane area being outside the image.

After transforming the reception information by the Radon inversion, the location of the unknown medium in the tray (the white box in Figure 3) and the geometry are obtained, as shown in the following figure.

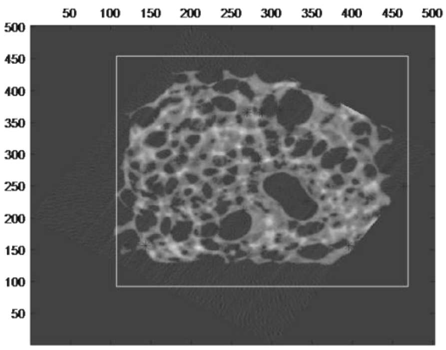

Fig. 3: The restored image after Radon inversion

3. Setting up a point coordinate transformation model and determining the absorption rate of the unknown medium

Step 1: he direct coordinate system Oxy is established based on the geometric center of the pallet, then the right angle coordinate system $O'x'y'$ is set at the origin of the rotation center.

Step 2: Determine the O' coordinates (x_0, y_0) under the coordinate system Oxy, and determine the angle of the x axis and the x' axis.

Step 3: Coordinate conversion formula is:

$$\begin{cases} x = x'\cos t - y'\sin t + x_0 \\ y = x'\sin t + y'\cos t + y_0 \end{cases}$$

$(x, y), (x', y')$ is the coordinates of the point M in the two coordinate systems.

The coordinates of the 10 positions and the absorptivity of the medium is obtained by Matlab, as shown in table 1.

Table 1: The original location of 10 points and the absorption rate of medium

Abscissa	Ordinate	Absorptivity
10.0000	18.0000	0.0000
34.5000	25.0000	0.0000
43.5000	33.0000	0.4899

45.0000	75.5000	0.0165
48.5000	55.5000	0.4895
50.0000	75.5000	0.0000
56.0000	76.5000	0.0000
65.5000	37.0000	0.5055
79.5000	18.0000	0.0000
98.5000	43.5000	0.0005

V. CONCLUSION

In this paper, we investigate the pretreatment of CT system in X-ray receiving data and eliminate the metal artifacts with linear interpolation. The medium geometric information and the position in the pallet are restored by using received data after processing (Figure 3). The original location of 10 points and the absorption rate of medium after rotating have been found. (as shown in Table 1).

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