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Reconstruction Model of CT System Based on Radon Inverse Transform

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Abstract. This paper solves the problem of how to calibrate the parameters of a CT system with a structure-known template. We used the method of radon inverse transformation. The calibration parameters include three aspects: the distance of the detector unit, the rotation center of the CT system in the square tray position, and the direction of the X-ray. The detector unit spacing is 0.2759mm. The position of the rotation center of the CT system in the square tray is (-9.3806,5.5180).The initial angle of X-ray is 30.0400° for each increase 1° . At the end, this paper analyzes the error and obtains the rationality of its results.

Introduction

CT (Computed Tomography) can be used in the case of no damage to the sample, using the radio energy absorption characteristics of the sample of biological tissue engineering and materials were tomography. Thereby we could obtain the structure information inside the sample. A typical two-dimensional CT system is shown in Fig. 1, parallel to the incident X-ray perpendicular to the detector plane, each detector unit as a receiving point, and equidistant arrangement. The X-ray emitter and detector relative position are fixed, and the entire transmit-receive system rotates 180 times counterclockwise around a fixed rotation center. For each X-ray direction, a two-dimensional fixed medium, which is fixed at position, is measured on a detector with 512 equidistant units to absorb the radiated energy after attenuation, and 180 groups of received information are obtained after gain processing.

Installing the CT system often happens with error, which would affect the image quality, so the need for the installation of the CT system parameters calibration, that is, with the known structure of the sample (called the template, in Fig. 2) calibration CT system parameters, and accordingly on the unknown structure of the sample. The CT system basic parameters include the spacing of the detector units, the center of the rotation of the tray and the 180 directions of the X-ray. To obtain these parameters, the solution bases on the elliptical geometry.

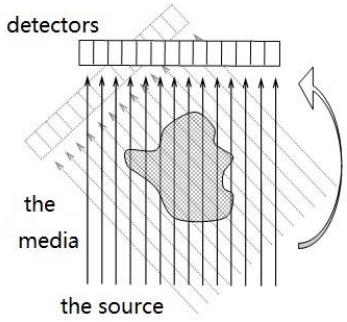

Figure 1. CT system diagram

Calculation of Calibration Parameters for CT.

The Spacing of the Detector Units. By the subject condition, the detector has 512 equidistant units, just know that a certain number of units corresponding to the geometric length to get its unit interval by $d = \frac{l}{n}$, In the process of imaging, the transmitter-receiver system rotates 180 times counterclockwise around a fixed rotation center, and observes the information of each point of the

annex 2 template. It can visually get the smooth conversion of the edge information of the template and no duplicate data. The symmetry of the template and the CT system a total of 180 times the rotation of the title conditions, you can approximate that its continuous rotation on the space.

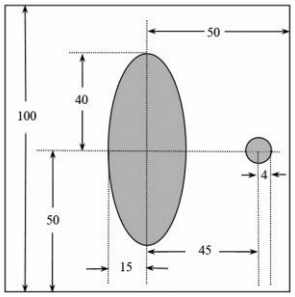

Figure 2. Template schematic

In the 180 revolutions, in order to simplify the calculation of geometric length, we selected two special positions, the light perpendicular to the square tray edge incident, see Fig. 3, Fig. 4, for further analysis of the subsequent analysis, we selected Fig. 3 , The corresponding "zero section" is the shortest, the middle of the "zero section" for the longest, the range of 150 to 152 columns of data, taking into account the detector receiving unit arranged in the space Discrete type and the continuity of the rotation in space, we use column 151 as the data of the state of Fig.3.

In the state of Fig. 3, the sum of the geometrical lengths of the "nonzero segment" at both ends and the middle "zero segment" is l'=45+15+3=64mm. The corresponding total number of divisions is n'=278-45-1=232.So we could get the result is $d = 0.2759\text{mm}$.

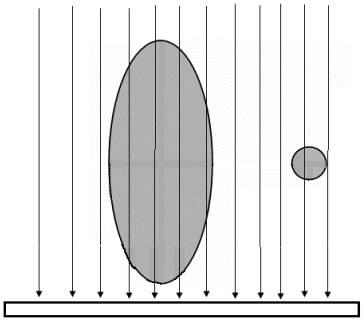

Figure 3. position 1

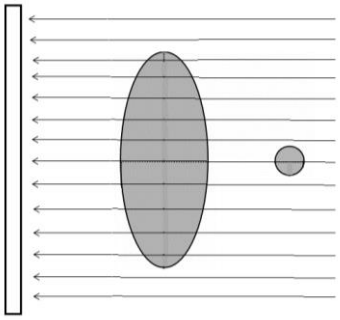

Figure 4. position 2

The Center of the Rotation Center in the Tray. According to the information obtained, the main theoretical basis of the CT scanner is the mathematical transformation of the Rada[1], the essence of the two-dimensional Radon transformation is straight along the line, in this question is the object of the cross-section attenuation coefficient The integral of the path of the cross section of the object is detected[2], and the image reconstruction is the inverse transformation of the integral.

The data of the access information is written as a matrix [3]. If this matrix is used directly, the reconstruction of the image will result in the reconstruction of the incomplete image in the

subsequent Iradon inverse transformation. We expand the matrix, On the above, the next to join the 107 rows and 180 columns of the zero matrix, will not affect the inverse transformation, constitute 726 rows and 180 columns of matrix, which use MATLAB iradon function to filter back projection reconstruction[1] Obtain the iradon inverse transformation matrix is [A], At the same time you can use the imagesc function to draw the reconstructed image, see Fig. 5, the vertical and horizontal coordinates of the length, the coordinates of the origin of the square tray center, square tray edge for the white frame, the center of the peripheral square for the rotation center, see appendix. In the obtained matrix [A], According to the CT imaging principle, it can be seen that the rotation center of the CT system should be the center of [A]. The center of the square tray is the center of the ellipse, in the matrix. From the above-mentioned detection unit spacing 0.2759mm we can calculate the position of the elliptical circle relative to the center of the square tray is O(-9.3806,5.5180).

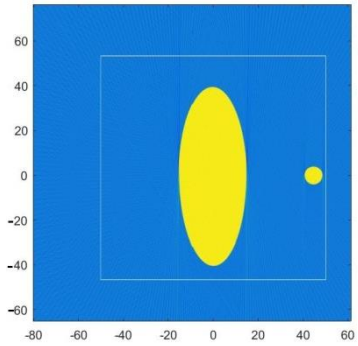

Figure 5. Reconstructed image

180 Directions of the X-ray. Before determining the 180 directions of the X-ray used by the CT system, the radiation energy after the absorption of the information obtained by the detector is subjected to gain processing and is not intuitive. Therefore, we need to restore the received information to the relevant medium Absorbs the energy of the attenuated ray and obtains a function expression that affects the energy of the ray.

After reading the information[2], the incident intensity of the X-ray, which is I, through the thickness of the medium, which is l, the strength becomes, the relationship is, where the attenuation coefficient, in this question is 1, the strength of the loss, related.

For the state in Fig. 3, since we are known to receive information with the length of the media along the X-ray direction, matlab is used to fit it[5], and it is found that there is a strong positive correlation between the two, taking into account the strength of the data in the medium In the length of the relationship between the exponential relationship, which we also speculate that it is exponential growth, the fitting results obtained and the results of the test difference is too large, then use the matlab curve fitting toolbox, the relationship between the two is :

$$l=1.769a \tag{1}$$

The following analysis of the main body is shown in Fig. 6.

In the first step, the detector unit number of the X-ray passing through the center of rotation is obtained.

First defined [6], that the X-ray direction and the y-axis positive angle. In the detector position 1 state, immediately, at this time for the second column data, the simultaneous elliptic equation and the x-ray equation at this time are as follows:

$$(\frac{x}{15})^2 + (\frac{y}{40})^2 = 1^2 \tag{2}$$

$$x+9.3806=k(y-5.5180) \tag{3}$$

Find the length of the intersection of the X-ray and the ellipse, and use the formula of the received information and the length of the medium to convert the 151st column data into the length of the medium. According to the intersection length determined by the simultaneous equations, The

corresponding detector units are 257 and 189, depending on where the center of rotation is located away from the circle, the detector unit is 257.

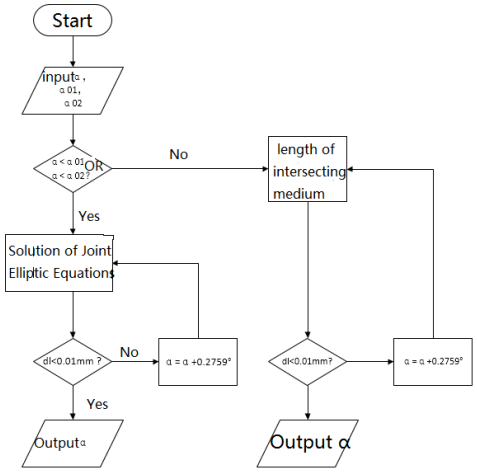

Figure 6. CT rotation angle analysis flow chart

The second step, when the CT scanner scanning X-ray through the media classification.

From the above calculation is available, No. 257 detection unit to receive the x-ray must pass through the rotation center, so now only on the 257 ray received x-ray analysis, the equation is

x+9.3806=k(y-5.5180)

By its path can be divided into two cases [7]: (1) x-ray only through the oval; (2) x-ray through the oval and round. The two cases are critical for the x-ray tangent to the circle, that is, the center of the circle to its distance is the radius of the circle and the result is 4.

It is based on the receipt status of the first column and accumulates it to obtain its exact angle. At this time, the state is x-ray only through the ellipse. First calculate the initial state of the x-ray and y-axis positive direction of the angle, first assume that it is 20 °, calculating the corresponding, straight line equation Eq.3 and elliptical equation Eq.2.

Find the intersection of two points [8], find the length of the ellipse through the ray length, 0.01 ° for the step, increasing the value of the same way to calculate the corresponding, until the satisfaction, find the corresponding, that is, Get answers.

After solving the first state, continue to calculate the next state, that is, the next column of the media state as the evaluation criteria, based on the calculation of the above state, continue to accumulate the calculation until the corresponding length of the corresponding length of the corresponding 2 Value less than, matlab procedures.

Fitting the relationship between 180 groups and the number of columns, that is, it is equal to the difference in accordance with 1 °increase, the procedure see annex.

From the above three links, we solved the detector unit spacing, the rotation center in the square tray position, for the CT system rotation of the 180 direction: the starting angle is that incremental counterclockwise rotation, the above income. The three results were analyzed:

For the detector unit spacing 0.2795mm, due to the detection of the receiver receive unit, the total number of bits is not fully accurate, in order to compensate for this error, we use the 151th column data on the sum of the three geometric length and its end The difference between the label is reduced by 1, the error caused by the interval of the unit is reduced to the maximum extent. The position of the rotation center in the tray is calculated by using the inverse of the radon inverse transform. Since this rotation is 180 times, it is enough The error of the algorithm is minimized, and the resulting image is highly similar to the original image. However, in the process of calculating the relative position of the two centers in the reconstructed image, the matrix coordinate difference is multiplied by the previously obtained detector. The spacing of the cells is the same as that of the detector, and the error of the detector unit spacing is not possible due to its own calculation. Therefore, the error of the rotation center in the tray position is spaced from the detector unit The error level is consistent; the calculation of the 180-direction rotation of the CT system is based on

the length of the X-ray penetrating medium. The cumulative calculation of the length of the X-ray penetration medium has two sources of error, one is the cumulative accumulation of time , And the other error is derived from the determination of the detector that always receives the detector through the center of rotation, resulting from the discretization of the detector unit.

Taking into account the sources of all errors [9], it is found that the three computational errors are derived from the discretization of the detector unit. For the purposes of this question, it is determined by the appropriate range [10] based on the error, and the error due to the discretization This question is permissible for the instrument itself.

Summary

Finally, we could get the spacing is 0.2759mm, the position of the rotation center of the CT system in the square tray is (-9.3806mm, 5.5180mm) and the initial angle of the X-ray is 30.0400°, which is obtained for each increase 1°.

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