Automatic classification of CT images of cerebral hemorrhage in dicom format based on BP neural network

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Abstract. This paper presents a method that can scan all the DICOM format CT images of cerebral hemorrhage in the specified folder and automatically analyze the parameters of the hemorrhage area. The automatic segmentation of cerebral hemorrhage area and brain tissue area is realized by threshold method, and the volume of cerebral hemorrhage area and brain tissue area is calculated according to the layer height and resolution parameters of Dicom format image. The proportion of hemorrhage area to brain tissue is calculated. Then, the position information of hemorrhage area and the percentage of hemorrhage area in brain tissue are used as the input of BP neural network to realize the automatic classification of the severity of cerebral hemorrhage.

1. Introduction

Intracerebral hemorrhage refers to the hemorrhage caused by non-traumatic vascular rupture in brain parenchyma, accounting for 20% - 30% of all stroke, and the mortality in acute stage is 30% - 40%. Patients with cerebral hemorrhage often suffer from sudden onset due to emotional excitement and exertion, and the early mortality is very high.

After the cerebral hemorrhage patient completes the CT examination, the radiology technician transmits the CT image to the doctor through the network, then the doctor carries on the diagnosis. However, the number of patients diagnosed by doctors every day is generally more than 100 [1-2], so it is difficult to make timely diagnosis and treatment for patients at high risk of cerebral hemorrhage in the first time.

At present, FCM algorithm is commonly used to segment the hemorrhage area in CT image of cerebral hemorrhage. Compared with the threshold segmentation method proposed in this paper, the disadvantage of FCM algorithm is that the operation speed is slow. Finally, BP neural network is used to realize the automatic classification of cerebral hemorrhage, reduce the diagnosis and treatment time of high-risk patients with cerebral hemorrhage, and save patients' lives in the shortest time.

2. Parameter reading of brain hemorrhage image in DICOM format based on MATLAB

In the clinical diagnosis of CT image, each tissue is distinguished by CT value. And reading the value of every pixel in DICOM image through MATLAB is reflected by gray value [4-5]. Therefore, we can convert CT value to gray value through the conversion formula of CT value and gray value, and the
conversion formula is shown in Formula 1. In Formula 1, Hu is the CT value, m is the parameter rescale-slope, b is the parameter rescale-intercept, and GV is the gray value.

\[
   \text{HU} = m \times \text{GV} + b
\]  

(1)

The matlab code to read the reset-slope value and the reset-intercept value from the DICOM file is as follows:

```matlab
Metadata = dicominfo ('CT Image file name');
m = metadata.RescaleSlope;
b = metadata.RescaleIntercept;
```

In order to calculate the volume of bleeding area and brain volume, we also need to obtain image spatial resolution and layer thickness parameters through DICOM format image. Set the length and width of pixels as Juli 1 and Juli 2 respectively, and the layer thickness as houdu. Matlab code is as follows:

```matlab
juli1 = metadata.PixelSpacing(1);
juli2 = metadata.PixelSpacing(2);
houdu = metadata.SliceThickness;
```

3. Automatic segmentation of cerebral hemorrhage area

In MATLAB, the dicomread function is used to read CT images, Normalize it, as shown in Figure 1(a). The contrast of brain tissue area is poor. Linear stretching is performed on the pixels with CT value range of 0 to 80 to improve the contrast of brain tissue area. The stretched image is shown in Figure 1(b).

![Matlab normalized cerebral hemorrhage image](image1)

(a) Matlab normalized cerebral hemorrhage image

![Gray linear stretched image](image2)

(b) Gray linear stretched image

**Figure 1.** Effect of linear stretch on cerebral hemorrhage image.

The range of CT value in the area of cerebral hemorrhage is between 40 and 70. Set the original image as F1 (x, y), as shown in Figure 2 (a). If \( 40 < F1(x,y) < 70 \), \( G1(x,y) = 1 \), else \( G1(x,y) = 0 \), get the output image as G1 (x, y), carry out binary morphological operation on G1 (x, y), retain the maximum connected component, and obtain the bleeding area template, as shown in Figure 2(b). Set the number of pixels in the bleeding area to \( N_{u1} \).
4. Automatic segmentation of brain tissue region

The CT value range of brain tissue area is between 0 and 80. Let the original image be F2 (x, y), as shown in Figure 3(a). If 0<F2(x,y)<80,G2(x,y)=1, else G2(x,y)=0, the output image is G2 (x, y), as shown in Figure 3(b) carry out binary morphological operation on G2 (x, y), and retain the maximum connected component to obtain the bleeding area template, as shown in Figure 3(c). Set the number of pixels in brain tissue area to Nu2.

5. Calculation of volume of hemorrhage area, volume of brain tissue area and proportion of hemorrhage area to brain tissue

The three-dimensional reconstruction of the cerebral hemorrhage area in all layers is shown in Figure 4. For the i-th layer image, the area S1i of the bleeding area of the i-th layer CT image is calculated by formula 2. The area S2i of the brain tissue region of the i-th layer CT image is calculated by formula 3.

\[ S1i = \text{juli1} \times \text{juli2} \times \text{Nu1} \]  
\[ S2i = \text{juli1} \times \text{juli2} \times \text{Nu2} \]

According to formula 4, using houdu, the thickness information of DICOM file, the volume V1i of cerebral hemorrhage area from layer i to layer i+1 is approximately calculated. Through formula 5, the volume V2i of the brain tissue area from the i-layer to the i+1-layer is approximately calculated. By formula 6, the volume of all cerebral hemorrhage was added to obtain the approximate value of the total volume of cerebral hemorrhage. Through formula 7, the volume of all brain tissues is added to obtain the approximate value of the total volume of brain tissues. According to formula 8, the proportion of hemorrhage area to brain tissue area was calculated.

\[ V1i = S1i \times \text{houdu} \]  
\[ V2i = S2i \times \text{houdu} \]
\[V_{\text{Volume of bleeding area}} = \sum V_{\text{i}}\]  \hfill (6)

\[V_{\text{Volume of brain tissue}} = \sum V_{\text{2i}}\]  \hfill (7)

\[P = \frac{\sum V_{\text{i}}}{\sum V_{\text{2i}}}\]  \hfill (8)

6. Obtain the location information of cerebral hemorrhage

Set the CT image size of the i layer cerebral hemorrhage as A * B, take the image center coordinate as (A / 2, B / 2), and calculate the average value Di of the distance from all pixels in the cerebral hemorrhage area to the image center. Calculate the average distance D from the bleeding area to the center of the image through formula 9.

\[D = \frac{\sum Di}{\text{Number of bleeding images}}\]  \hfill (9)

7. Automatic classification of CT images of cerebral hemorrhage by BP Neural Network

BP neural network has two inputs, P (formula 8) and D (formula 9) are used as input data of neural network. Cerebral hemorrhage was divided into mild, moderate and severe. The BP neural network has an output y, mild cerebral hemorrhage (y=0), moderate cerebral hemorrhage (y=1), and severe cerebral hemorrhage (y=2).

Each type has 5 training sets and 2 test sets. After obtaining the network through the training set, the network is verified through the test set. Where the network mean square error is set to net.trainparam.goal=1e \(-3\). The number of iterations is net.trainparam.epochs = 10000. The effect of mean square error iteration is shown in Figure 5. When the iterative operation is more than 4000 times, the mean square error is very small.

![Figure 5. Mean square error iteration effect.](image)

Set T as the ideal output result (the first two columns 0 represent mild cerebral hemorrhage, the three to four columns 1 represent moderate cerebral hemorrhage, the five to six columns 2 represent moderate cerebral hemorrhage), is shown in table 1, A is the experimental output, is shown in table 2. Mean square error equal to \(\text{sum}(T - A)^2\) = 0.2049.

**Table 1. Ideal output T.**

| mild cerebral hemorrhage | mild cerebral hemorrhage | moderate cerebral hemorrhage | moderate cerebral hemorrhage | severe cerebral hemorrhage | severe cerebral hemorrhage |
|--------------------------|--------------------------|-------------------------------|-------------------------------|---------------------------|---------------------------|
| Example 1                | Example 2                | Example 1                     | Example 1                     | Example 1                 | Example 2                 |
Table 2. Experiment output result A.

|                | mild cerebral hemorrhage | mild cerebral hemorrhage | moderate cerebral hemorrhage | moderate cerebral hemorrhage | severe cerebral hemorrhage | severe cerebral hemorrhage |
|----------------|--------------------------|--------------------------|------------------------------|------------------------------|---------------------------|---------------------------|
|                | Example 1                | Example 2                | Example 1                    | Example 2                    | Example 1                 | Example 2                 |
| A              | 0.0543                   | 0.0637                   | 1.2521                       | 0.852                        | 1.714                     | 1.825                     |

8. Conclusions
The advantage of the threshold segmentation method in this paper is that its calculation speed is fast. The results of automatic segmentation of the brain hemorrhage area are compared with the results of manual segmentation, and the error is controlled within 5%. The results of automatic segmentation of the brain tissue area are compared with the results of manual segmentation, and the error is controlled within 1%. Finally, through the BP neural network, the automatic classification of cranio cerebro hemorrhage images is achieved, and the accuracy is high.

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Jiangxi Provincial Health and Family Planning Commission (20185515).
Development of early warning system for cerebral skull bleeding based on CT image processing (201810412008).

References
[1] Gong Yan Dong, Hong Qing Tu. Laser image contour detection based on QTSU method [J]. Laser magazine, 2019, 40(10):95-98.
[2] Hai Yang Luo. Research on the method of medical image 3D reconstruction based on improved MC algorithm [D]. Harbin University of science and technology, 2019.
[3] Yong Tian, Youqiong Li, Jingli Guo, Min Liu, Lue Su, Dewei Qu, Chengyu Lu. 2005. Digital measurement of brain volume and centroid.
[4] Wang Haojun, Yang Yan, Qu Ruina. Implementation of batch conversion of CT sequence images in DICOM format based on Matlab [J]. science and technology information, 2017,15 (12): 8-11.
[5] Guo Fei. The diagnostic value of CT in the location, volume and prognosis of cerebral hemorrhage [J]. Clinical medicine research and practice, 2018, 3 (32): 159-161.