

Research on Image Retrieval Method of Medical Equipment Based On Multi Feature Hierarchical Fusion

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Abstract. To solve the problem of medical equipment image retrieval, an image retrieval method based on multi-feature hierarchical fusion is proposed. This method uses color moments to calculate the color features of the image, LBP operator to calculate the texture features of the image, Fourier descriptor to calculate the shape features of the image, through hierarchical weighted fusion method to fuse the three types of features within a similarity measure, and finally form the basis for retrieval and judgment. Based on the experimental results of endoscopic images and CT images, the results confirm the effectiveness of the proposed method. With the increasing requirement of recall rate, the precision of the proposed method is obviously higher than that of the three single feature retrieval methods, which is suitable for medical image retrieval.

1. Introduction

With the widespread use of endoscopy, CT and other visual medical equipment in clinic, medical equipment image has become an important basis for assisting doctors to make medical diagnosis [1]. Tens of thousands of medical equipment images have been incorporated into the case database and become a powerful auxiliary means for new case diagnosis. Judging which image is similar between the new case image and the case database depends on image retrieval technology [2].

Image retrieval technology has three important branches, one is text-based image retrieval technology, the other is content-based image retrieval technology, the third is semantic-based image retrieval technology [3]. Text-based image retrieval requires text annotation and has a high false-detection rate; semantic gap restricts its practicality in semantic-based image retrieval; content-based image retrieval, which uses similarity of certain image features to determine retrieval results, is the most widely used graph at present. Like search technology [4].

Content-based image retrieval technology takes a certain feature of the image as the expression of content information, and then constructs similarity measure to complete the retrieval process. Color features, texture features and shape features are all commonly used feature [5-6] in image retrieval. In addition, there are also many abstract features used in image retrieval, such as wavelet features, phase features and so on [7].



Medical equipment image often contains a variety of features, relying on a single feature for image retrieval, the results obtained lack of reliability [8]. In this paper, an image retrieval method based on multi-feature hierarchical fusion is proposed, which combines color feature, texture feature and shape feature to improve the retrieval performance.

2. Color feature extraction

Color feature is the most abundant feature in image content information, so it is widely used in the feature set of image retrieval technology. For image retrieval technology, color features have some outstanding characteristics, such as size invariance, direction invariance. From the perspective of implementation, color features are also easier to extract. Among the various image retrieval methods, the color features that have been used include color histogram feature, color autocorrelation feature and color moment feature.

In the process of multi feature fusion, we choose the color moment feature. Color moment features have the general attributes of color features, which can be obtained by statistical calculation of pixel color information, and the calculation of abstract vector is faster. In this paper, three color feature vectors are selected to participate in the image retrieval process.

The first order color moments are calculated, as shown in Formula 1.

$$C_1 = \frac{1}{W \times H} \sum_{i=1}^{W \times H} P(i, j) \quad (1)$$

In the formula, C_1 represents the first color moment, W 、 H represents the width and height of the image, and $P(i, j)$ represents the color information of pixels at position (i, j) .

The calculation of the second order color moments is shown in formula 2.

$$C_2 = \sqrt{\frac{1}{W \times H} \sum_{i=1}^{W \times H} [P(i, j) - C_1]^2} \quad (2)$$

In the formula, C_2 stands for the second order color moment.

The calculation of the third order color moments is shown in Formula 3.

$$C_3 = \sqrt{\frac{1}{W \times H} \sum_{i=1}^{W \times H} [P(i, j) - C_1]^3} \quad (3)$$

The C_3 in the formula represents the third order color moment.

3. Texture feature extraction

Texture features represent the regular arrangement of image contents. Human organ images and lesion images contain rich texture information. Therefore, texture features are selected as the first important expression of medical equipment image content information in the image retrieval method.

The commonly used texture features are texture based on gray level co-occurrence matrix, Tamura texture, Gabor texture, etc. These textures have high computational complexity. For this purpose, LBP texture features are used in this paper.

Assuming that the template area is 3×3 pixels, $f(x_c, y_c)$ represents the region.

The center pixel is first two valued, as shown in formula 4.

$$s(g_i, g_c) = \begin{cases} 1 & g_i \geq g_c \\ 0 & g_i < g_c \end{cases} \quad (4)$$

In the formula, g_c represents the gray level of the center pixel, and g_i represents the gray level of other pixels in the neighborhood.

After traversing all the pixels in the region, a binary number formed by the binarization result of neighborhood pixels can be obtained. The LBP texture of the center pixel can be calculated as a decimal number instead of the center pixel, as follows:

$$LBP = \sum_{i=0}^7 s(g_i, g_c) 2^i \quad (5)$$

When the template image traverses the whole image, the LBP texture image corresponding to the original 5 images can be obtained, which is illustrated in Figure 1.

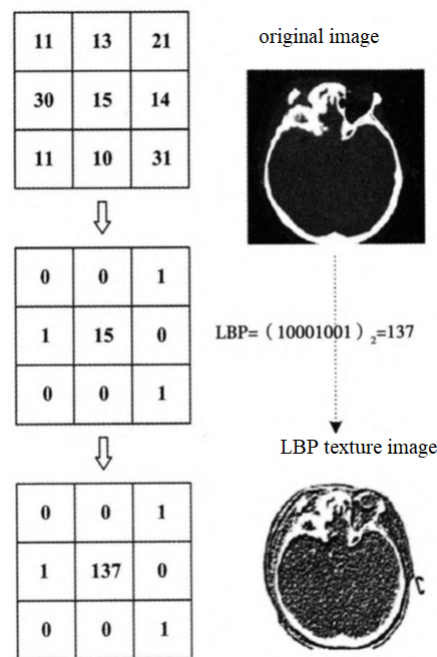


Fig.1 LBP texture feature generation process and effect

LBP texture feature expression can effectively improve the contrast of different texture regions, and it has low computational complexity and fast computational speed.

4. Shape feature extraction

In medical equipment images, the patient's organs and lesion areas have not only rich texture features, but also full shape features, such as contours, edges and so on.

Therefore, in the feature fusion image retrieval method constructed in this paper, we also need to calculate the shape features in the image content. Shape features need to satisfy the invariance of geometric elements such as translation, rotation, scale and so on.

In this paper, Fourier shape descriptor is selected to calculate image shape features during retrieval.

First, each pixel in the image is expressed in plural form.

$$s(k) = X(k) + jY(k) \quad (6)$$

In the formula, $X(k)$ represents the abscissa of each pixel, and $Y(k)$ represents the ordinate of each pixel.

Secondly, the Fourier shape descriptor of the whole image is calculated.

$$F = \frac{1}{N} \sum_{k=0}^N s(k) e^{-\frac{2\pi w k}{N}} \quad (7)$$

In the formula, N represents the total number of pixels of the image.

5. Similarity design of hierarchical fusion

Medical equipment images contain abundant color features, texture features and shape features at the same time. Therefore, in the design of image retrieval method, three features are fused together to construct similarity measure for retrieval judgment.

First, the similarity measure of color features between query image and database image is constructed.

$$Sim_c = \sum_{i=1}^3 \beta_c^i |C_i^Q - C_i^D| \quad (8)$$

In the formula, β_c^i represents the first layer weight and is used to limit the contribution of three color feature vectors to the overall similarity measure of color features.

Secondly, the similarity measure of texture features between query image and database image is constructed.

The LBP value of each pixel in the two images is calculated, and a statistical histogram is formed. Then the probability p_i of $LBP = i$ can be calculated. Thus the similarity of LBP texture features of the two images can be calculated.

$$Sim_T = \sum_{i=1}^n P_{Qi} \log \frac{P_{Di}}{P_{Qi}} \quad (9)$$

In the formula, Q represents the query image, and D represents the database image. Thirdly, the similarity measure of shape features between query image and database image is constructed.

$$Sim_s = \frac{F_D}{F_Q} \quad (10)$$

Finally, a global similarity measure is constructed by combining color features, texture features and shape features.

$$Sim = w_c Sim_c + w_T Sim_T + w_s Sim_s \quad (11)$$

In the formula, w_c represents the weight of texture feature similarity in the overall similarity judgment, w_T represents the weight of texture feature similarity in the overall similarity judgment, w_s represents the weight of character feature similarity in the overall similarity judgment, and has $w_c + w_T + w_s = 1$.

For different images, the size of w_c , w_T , w_s is also different. Images with richer texture features have larger w_T and vice versa.

Compared with β_c^i , w_c , w_T , w_s which constitutes the second layer weight, the similarity measure of image retrieval in this paper, three features are fused together by layered weighting, so it is called multi-feature hierarchical fusion image retrieval method.

6. Experimental results and analysis

In order to verify the effectiveness of the method, the following experiments are carried out. A small image database was constructed with the medical equipment images of our hospital. There were 1000 cases images, which were divided into 8 categories.

The results of retrieving endoscope images are shown in Figure 2.

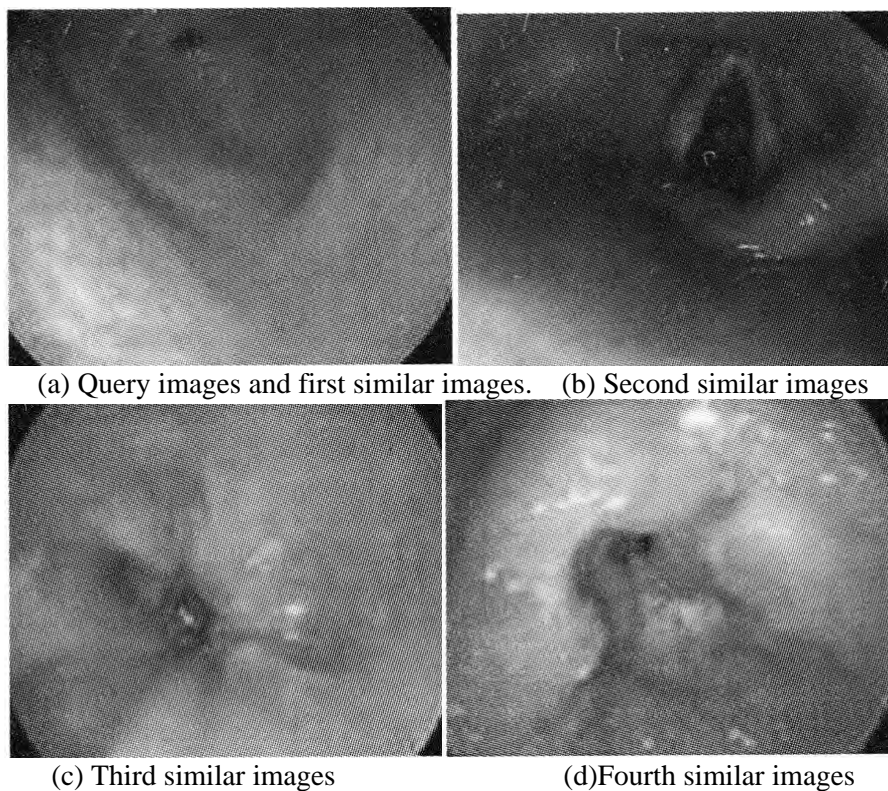


Fig. 2 Retrieval results of endoscopic images

In Figure 2, the first image is the query image, which is also the most similar image in the retrieval results. The similarity between the latter three images and the query image decreases in turn. For CT image retrieval, the result is shown in Figure 3.

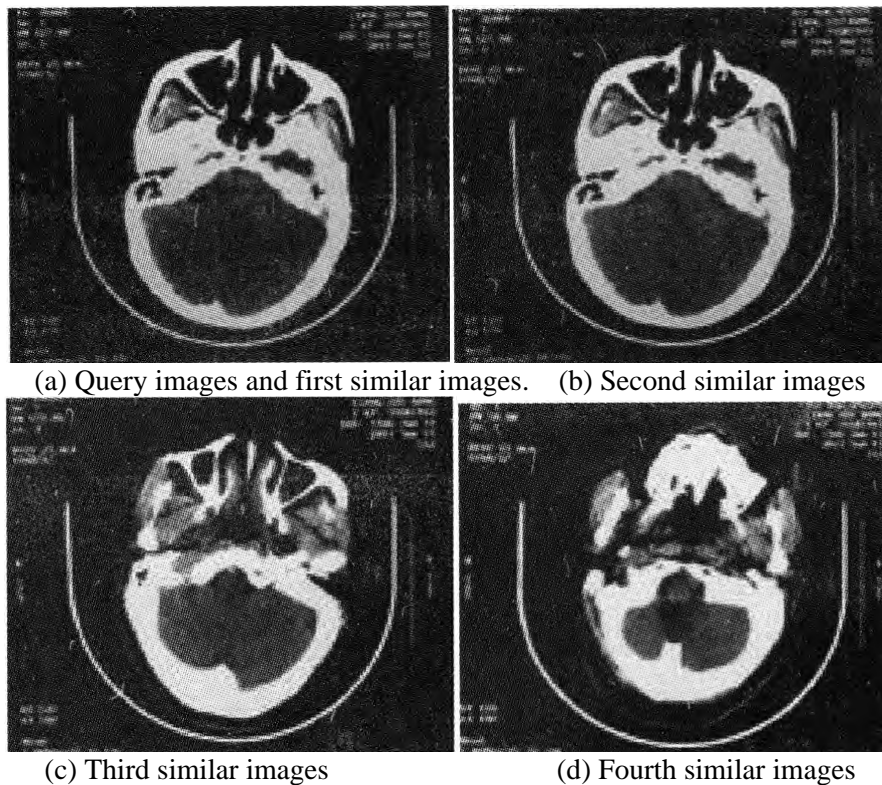


Fig. 3 retrieval results of CT images

The two sets of experimental results given in figures 2 and 3 show that:

Firstly, for the speculum image and CT image, the image retrieval method based on multi-feature fusion can obtain ideal retrieval results. Case images similar to query images are retrieved, which can play an effective auxiliary role in the diagnosis of new cases.

Secondly, because color feature, texture feature and shape feature are used at the same time, this method can be applied to both specular images with richer color feature and CT images with richer texture feature, which makes this method can be applied to a wider range.

Next, we further test the accuracy and recall of the proposed method. 200 cases were selected to construct a small image database, and 0.2 was taken as the step. The change of precision rate of this method was investigated step by step with the improvement of recall rate. Accordingly, the recall ratio curve of this method is shown in Figure 4.

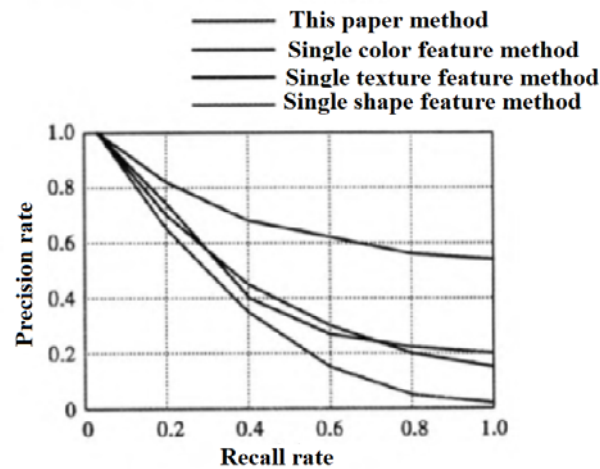


Fig.4 Comparison of precision rate and recall rate

As can be seen from the results in Figure 4, with the recall requirement from 0.2 to 1.0 (that is, from 20% to 100%), the precision of retrieval methods based on a single color feature and based on a single texture feature is reduced to about 20%; the precision of retrieval methods based on a single shape feature is reduced to 2% left. Right.

Compared with the three retrieval methods based on single feature, the precision of image retrieval method based on multi-feature fusion is still close to 60% with the requirement of recall from 0.2 to 1.0. This fully illustrates the accuracy and efficiency of this method.

7. Conclusion

Aiming at the problem of medical equipment image retrieval, an image retrieval method based on multi-feature hierarchical fusion is proposed. This method combines color moment feature, LBP texture feature and Fourier shape feature to construct similarity measure for retrieval judgment. The experimental results show that the precision of this method is obviously higher than that of single feature image retrieval method, and the advantages of this method are gradually expanded with the increase of recall rate.

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