

Content Based Medical Image Retrieval System using SIFT and Hu-Moment for Hepatobiliary Images

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Abstract: This study presents retrieval of hepatobiliary images based on content-based medical image retrieval technique. Hepatobiliary images are related to hepatobiliary diseases. Hepatobiliary diseases include a group of diseases related to liver and biliary system. For image retrieval, low-level feature is used. For feature extraction sift (scale invariant feature transform) and Hu-moments methods are used. Features extracted by these methods are combining to form a single feature vector. Feature extracted by query images and images which are stored in the database are compared using Euclidean distance method. Based on minimum distance images are retrieved. For performance measurement precision, recall and error rate are measured.

Key words: Scale Invariant Feature Transform (SIFT), Content Based Medical Image Retrieval (CBMIR), Difference of Gaussian (DOG), Hu-moment, Euclidean distance, precision, recall

INTRODUCTION

Content Based Medical Image Retrieval (CBMIR) system uses the low level feature for image retrieval. CBMIR is more efficient compare to text-based approach. Color, texture and shape are used as a low level feature. These features are derived from the image itself. SIFT (Scale Invariant Feature Transform) is invariant to image scale, rotation and translation. Now a days, sift are used to describe the content of images. Local features are presented by sift. Sift mainly detect keypoints and descriptors from the image. Then, these are used to find the similar image from the database compares to query image. Content-based image retrieval using sift for binary and grayscale images was presented in 2014 (Bakar *et al.*, 2013). In this approach, researcher show the excellent experimental result for the image retrieval. A comparative study of sift and PCA for content based image retrieval was presented by Reddy and Narayana (2016). In this study researcher got better image retrieval performance compare to PCA approach. Mohammed Alkhwilani, Mohammed Elmogy and Hazem Elbakry use SIFT approach for content-based image retrieval (Alkhwilani *et al.*, 2015). A survey research paper for content-based image retrieval system using SIFT was presented in 2014 (Velmurugan, 2014). Hu-moment is used for shape feature extraction. A comparative study on Feature extraction using texture and shape for content based image retrieval was presented in 2015 (Bagri and

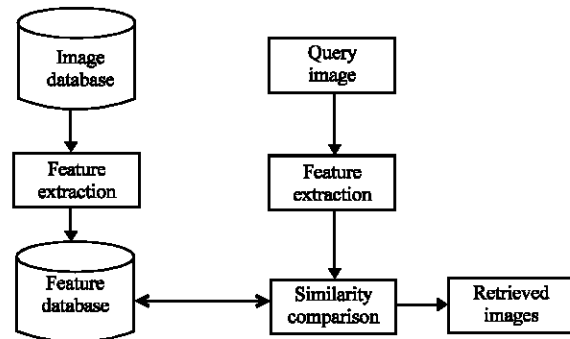


Fig. 1: General CBIR system architecture

Johari, 2015). In this study researcher has used Hu-moment for shape feature shape feature extraction (Zhao *et al.*, 2016). A basic block diagram for content-based image retrieval is shown in Fig. 1 (Ramamurthy *et al.*, 2012). In this CBIR system, feature extracted from the database are compared with query feature. Similar images are retrieved based on minimum distance.

MATERIALS AND METHODS

Proposed work: For feature extraction, SIFT and Hu moment algorithm are used. Block diagram for proposed work is shown in Fig. 2. Algorithm discussed stepwise are as follow:

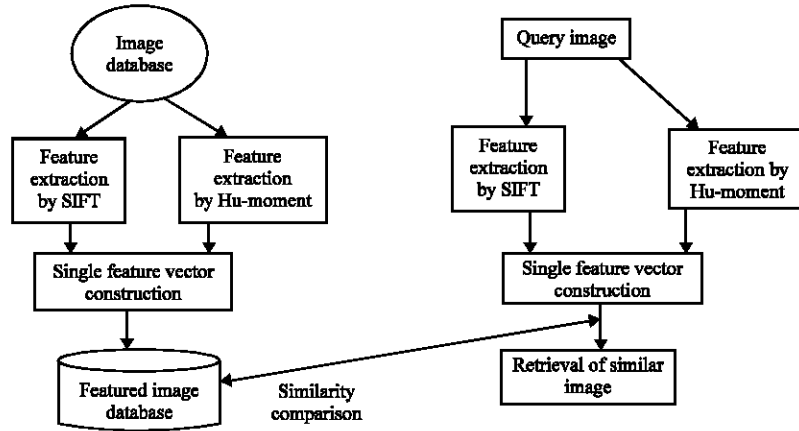


Fig. 2: System flow diagram

- Step 1: create a database containing various hepatobiliary images
- Step 2: extract features using SIFT and Hu-moment.
- Step 3: both these feature vector are combined to form a single feature vector
- Step 4: distance between the feature vector of query images and the database images are calculated
- Step 5: based on minimum distance images are retrieved

$$D(x) = D + \frac{dD^1X}{dx} + \frac{1}{2}XT \frac{d^2DX}{dx^2} \quad (4)$$

where, D is the difference of Gaussian. Then, the extrema X is determined by:

$$X = \frac{-d^2D^{-1}}{dx^2} \frac{dD}{dx^2}$$

Feature extraction by SIFT: Steps for SIFT algorithm are discussed.

Hessian matrix is used to find local maxima:

Step 1 (scale-space extrema detection): Difference of Gaussian (DOG) function is used to detect extrema points:

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \quad (1)$$

Where:

$L(x, y, \sigma)$ = Represents the scale space of an input image ($I(x, y)$)

$G(x, y, \sigma)$ = Variable scale gaussian function

* = The convolution operator

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

Stable keypoints are detected by using the equation given (Eq. 3):

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma) \quad (3)$$

where, k is a constant multiplicative factor (Lowe, 2004).

Step 2 (keypoint location): Taylor expansion series are used to localize the stable keypoints:

$$H = D_{xx} \ D_{xy} \ D_{yy}$$

Where:

$$D_{xx} = D(x, y-1) - 2D(x, y) + D(x, y+1)$$

$$D_{yy} = D(x-1, y) - 2D(x, y) + D(x+1, y)$$

$$D_{xy} = D(x, y-1) - 2D(x, y) + D(x, y+1) - D(x-1, y) + D(x+1, y)$$

$$\text{Tr}(H) = D_{xx} + D_{yy} = a + B;$$

$$\text{Det}(H) = D_{xx} \ D_{yy} - (D_{xy})^2 = a \times B;$$

$$\text{Ratio} = (a+B)^2 / a \times B$$

Hessian matrix is calculated for each keypoint selected by second order derivative of D. Keypoints are removed which having a value less than ratio. Figure 3 represents keypoints for Fig. 4.

Step 3 (orientation assignment): Based on local image gradient directions one or more orientation is assigned to each keypoint (Lowe, 2004).

Step 4 (keypoint descriptor): At each keypoint local image gradients are measured at selected scale (Lowe, 2004).



Fig. 3: Hepatobiliary diseases image



Fig. 4: Key point for figure 3

Feature extraction by Hu-moment: Hu-moment gives seven-moments. These moments are invariant to rotation, scaling and translation. Central moment is given by equation:

$$\mu_{p,q} = \sum (x-x_c)^p (y-y_c)^q f(x,y)$$

where, center of the object is given by (x_c, y_c) . Normalized central moment is given by equation:

$$\eta_{p,q} = \mu_{p,q} / \mu_{00}^{\gamma}$$

$$\gamma = \left\lceil \frac{p+q}{2} \right\rceil + 1$$

Seven-moment equation is given:

$$\varnothing 1 = \mu_{2,0} + \mu_{0,2}$$

$$\varnothing 2 = (\mu_{2,0} - \mu_{0,2})^2 + 4\mu_{1,1}^2$$

$$\varnothing 3 = (\mu_{3,0} - 3\mu_{1,2})^2 + (\mu_{3,0} - 3\mu_{2,1})^2$$

$$\varnothing 4 = (\mu_{3,0} + \mu_{1,2})^2 + (\mu_{3,0} + \mu_{2,1})^2$$

$$\varnothing 5 = (\mu_{3,0} - \mu_{1,2})(\mu_{3,0} + \mu_{1,2})[(\mu_{3,0} + \mu_{1,2})^2 - 3(\mu_{2,1} + \mu_{0,3})^2] +$$

$$(3\mu_{2,1} - \mu_{0,3})(\mu_{2,1} + \mu_{0,3})[3(\mu_{3,0} + \mu_{1,2})^2 - (\mu_{2,1} + \mu_{0,3})^2]$$

$$\varnothing 6 = (\mu_{2,0} - \mu_{0,2})[(\mu_{3,0} + \mu_{1,2})^2 - (\mu_{2,1} + \mu_{0,3})^2] +$$

$$4\mu_{1,1}(\mu_{2,1} + \mu_{0,3})$$

$$\varnothing 7 = (3\mu_{2,1} - \mu_{0,3})(\mu_{3,0} + \mu_{1,2})[(\mu_{3,0} + \mu_{1,2})^2 - 3(\mu_{2,1} + \mu_{0,3})^2] -$$

$$(\mu_{3,0} - \mu_{1,2})(\mu_{2,1} + \mu_{0,3})[3(\mu_{3,0} + \mu_{1,2})^2 - (\mu_{2,1} + \mu_{0,3})^2]$$

These seven moments are used to extract a feature from an image.

Feature vector construction: Feature extracted by SIFT and Hu-moment are combined to form a single feature vector. For combining one or more feature vector fusion methods are used. Sift features are fused to Hu-moment features to generate combined feature vector (Kavitha *et al.*, 2011).

RESULTS AND DISCUSSION

Image database is of three types 1; Radiology 2 and 3; Histlogy; Radiology database contains images related to hepatobiliary diseases which are taken by radiology imaging technique. Radiology database contains >200 images. Pathology database contains images related to hepatobiliary diseases which are taken by pathology imaging technique. Pathology database contains around 300 images. Histology database contains hepatobiliary diseases which are taken by histology imaging technique. Histology database contains >200 images. The proposed method has been implemented using Matlab (Fig. 5-10).

Image retrieval using euclidean method: The distance between the query image and database image are calculated by using Euclidean method (Veni and Narayanankutty, 2010). Threshold value is being set to 0.1 (Chandrakar *et al.*, 2011). By using this threshold value image is retrieved correctly. Euclidean distance method formula is given:

$$d(A^1, A^Q) = \sqrt{\sum_{i=1}^n (A_i^1 - A_i^Q)^2}$$

Where:

A^1 = The image in the database

A^Q = The query image for retrieval



Fig. 5: Query image for the radiology database

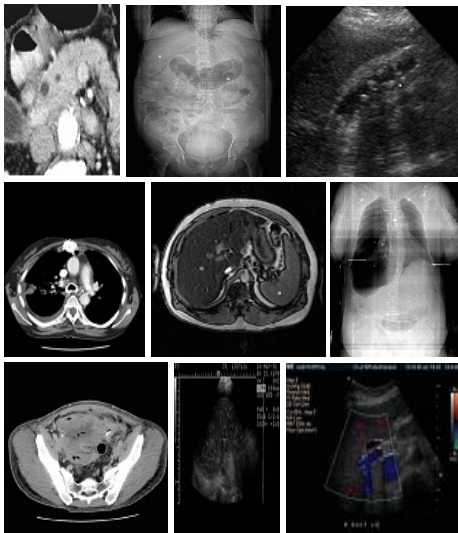


Fig. 6: Images in the radiology database



Fig. 7: Query image for the pathology database

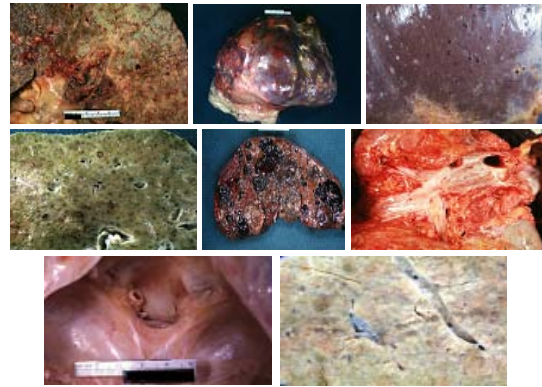


Fig. 8: Images in the pathology database

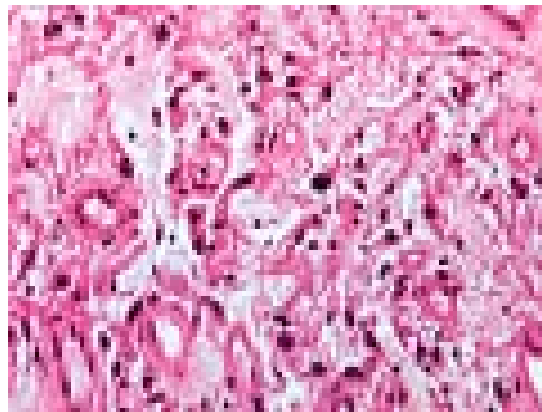


Fig. 9: Query image for the histology database

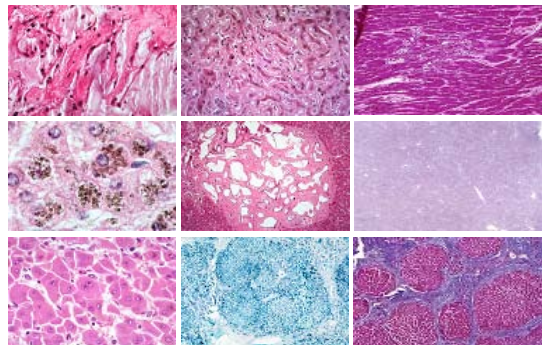


Fig. 10: Images in the histology database

Retrieval efficiency: Precision, recall and error-rate are measured for retrieval efficiency. Results are shown in Table 1-3. For performance measurement retrieval time are measured for all databases:

$$\text{Precision} = \frac{\text{No. of relevant images retrieved}}{\text{Total number of images retrieved}}$$

Table 1: Experimental results for radiology database

Database type	Precision (%)	Recall (%)	Error rate (%)	Time taken for retrieval in seconds
Radiology	94.71	100	5.28	3.6118

Table 2: Experimental results for pathology database

Database type	Precision (%)	Recall (%)	Error rate (%)	Time taken for retrieval in seconds
Pathology	95.04	100	4.95	4.109085

Table 3: Experimental results for histology database

Database type	Precision (%)	Recall (%)	Error rate (%)	Time taken for retrieval in seconds
Histology	94.58	100	5.41	3.6969

$$\text{Recall} = \frac{\text{No. of relevant images retrieved}}{\text{Total number of relevant images in the database}}$$

$$\text{The database error rate} = \frac{\text{No. of non-relevant images retrieved}}{\text{Total number of images retrieved}}$$

CONCLUSION

In this study, images are retrieved by using sift and Hu-moment feature vector. Both these features vectors are combined to form a single feature vector. The experiment is conducted for three types of image database. Precision, recall and error-rate are measured for retrieval efficiency. By using sift and Hu-moment performance of the system has been improved.

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