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Research Article

Performance Analysis on Discrete Wavelet and Curvelet Transform in Histology Image Retrieval

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Abstract

Content Based Image Retrieval (CBIR) plays a major role in decision making related to clinical activities. CBIR systems differ by the way of extracting features. Many feature extraction methods such as Zernike moments, Tamura, Gabor Texture, Scale-invariant feature transform, discrete cosine transform and Gray-level co-occurrence matrix are in practice. This paper proposes two feature extraction methods that use Curvelet and Wavelet Transforms. Further coefficient of variations is used in matching the similar images. Experimental results show that the proposed method is efficient in terms of precision and recall. Results shows that the proposed method is well suitable for histology images.

Keywords: *CBIR; Discrete Curvelet; Discrete Wavelet Histology Image; Image Retrieval.*

1. Introduction

The proposed method is focused on CBIR method (Akakin and Gurcan, 2012). Image retrieval is the process by which retrieving images from the large database giving similar image as input. The input images are called as query image. There are two approaches widely used in CBIR

1. Description Based Retrieval
2. Content Based Retrieval

CBIR uses the contents of the query image for retrieving similar image. The term content may refer to colors, shapes, textures or any other information derived from the image itself. The problem of image retrieval depends on accuracy, efficiency and scalability. This paper proposes wavelet and curvelet coefficients as features. CBIR technique includes feature extraction and similarity matching using Euclidean distance. In feature extraction the visual contents of the images are extracted and stored in database. To retrieve images, a user gives an image as input called query image. This query image may be an example image or sketched figure. Then the query features are extracted and the similarities between the query image and the database images are calculated and retrieval is performed with the indexed images (Sanjoy K. Saha, *et al*, 2008). Euclidean distance matching is used for comparing the image similarities. It compares the similarity of two images in various dimensions, depending on their features. The image distance measure of zero signifies an exact match between the images.

The image retrieval system was developed in 1990s. An image retrieval system used for searching, retrieving images according to the keyword, text. Text-based techniques can capture high level concepts. It is easy to issue text queries. But text descriptions are sometime subjective and incomplete, and cannot illustrate complex image features very well. But Content based image retrieval produces good result based on similarity.

VisualSEEk based CBIR integrates feature-based image indexing with spatial query. The integration relies on the representation of color regions by color sets (John R. Smith, *et al*, 1996). Local Similarity Patterns (LSP) based image retrieval using Region wise image similarity, it's obtained for optimization genetic algorithm based relevance feedback is proposed. The LSP allowing comparison of different image regions using different similarity criteria is more suited for modelling the human perception of image similarity (Zoran Stejic, *et al*, *2003*). The adaptive clustering and cluster-merging method are used to find multiple regions and their arbitrary shapes of contours for a given complex image query (Deok-Hwan Kim, *et al*, 2005). Modified Shape feature extraction for image retrieval used multi-texton histogram, it can present the spatial correlation of color and texture orientation (Srinagesh, *et al*, 2013). Content based microscopic image retrieval focusing on multi image query and slide level retrieval (Hartice Cinar Akakin, *et al*, 2012).

A detail review of CBIR analyzed the different techniques in CBIR (Deepak and Chavan, 2012). Relevance feedback is used to retrieve the similar images that are initially returned from a given query and to use information about whether or not those results are related to perform a new query. Relevance feedback approach captured more of the user's relevance judgments by

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allowing the use of natural language like comments on the retrieved images that uses methods from fuzzy logic and computational intelligence (Ronald, 2005).

In histology image retrieval method proposed the multi objective learning method. It optimizes the combination of visual features and it uses the combination of low level and high level feature extraction methods (Qianni Zhang, *et al*, 2013). The proposed discrete wavelet and curvelet transform is applied for texture feature extraction. The curvelet and wavelet transforms are used for multiresolution analysis and these perform well on both spatial and frequency domain.

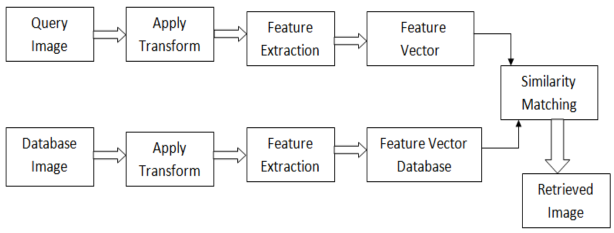


Fig. 1 Block diagram of CBIR.

The proposed approach is able to learn automatically the relative importance of each feature space corresponding to the keyword from its associating representative query group. Finally the performance is evaluated using precision and recall. The Fig.1 shows the block diagram of CBIR.

The remainder of this paper is organized as follows: Section 2 presents the proposed method. Section 3 introduces the feature extraction and Similarity matching. The evaluation procedure and experimental results are presented in Section 4 and Section 5 contains the Conclusion.

2. Proposed Method

The proposed method of content based image retrieval system uses wavelet and curvelet based feature extraction. The detailed block diagram of CBIR is shown in Fig.2.There are two important modules are performed in the proposed method; image insertion and image retrieval. The mean, standard deviation and coefficients of variations are calculated according to the coefficients. These features are considered as an image features, then the database is connected and the image features are stored in the database.

- Image insertion module
- Image retrieval module

The database is used in image insertion and retrieval operations. During the insertion, it works to store the extracted features of the images into device. In retrieval process it helps to retrieve the feature vectors as it contains.

3. Feature Extraction

Feature extraction is used to reduce the dimensionality of image. It transforming the input data into the set of features is called feature extraction. It Divide whole image into sub-blocks and then it extracts features from each sub-block. The proposed CBIR involves transform based feature extraction. Here the image domain is transferred to another domain and the coefficients are calculated. From the coefficients image features are calculated.

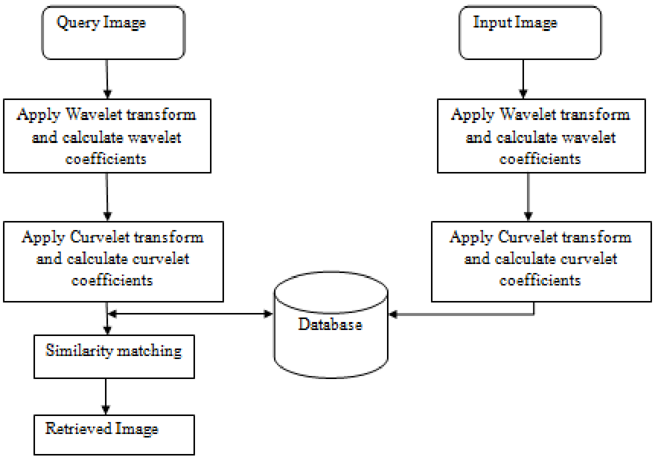


Fig. 2 Transform based CBIR

3.1. Discrete Wavelet Transform (DWT)

Wavelet transform is used to convert a spatial domain image into frequency domain. It provides the time frequency representation. The wavelet transform is created by repeatedly filtering the image coefficients on a row-by-row and column-by-column basis (Balamurugan and Anandhakumar, 2009). One level decomposition DWT equation is shown in equation (1).

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k] \quad (1)$$

where x is the given input image and *g* is the impulse response of the low pass filter. The discrete wavelet transform decomposition is shown in Fig. 3. Discrete wavelet transform can be performed by iteratively filtering an image through the low pass and high pass filters and through this the input image is decompose into a series of sub band images.

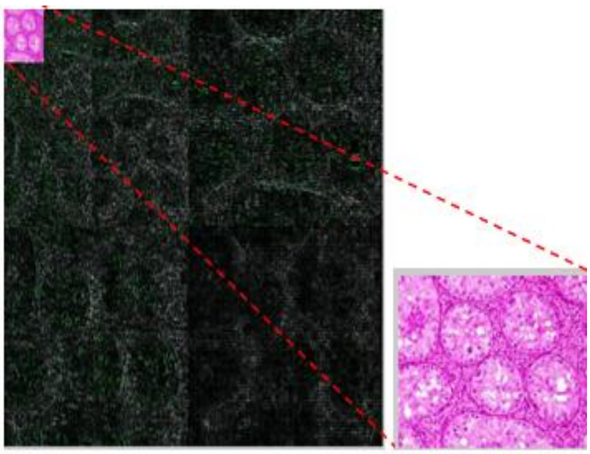


Fig. 3 Third level decomposition of Discrete Wavelet Transform

In the proposed method input image decomposed into 64 wavelet coefficients. Wavelets transform is computed separately for different segment of the time domain signal at different frequencies, and it well worked in the signal discontinuity.

3.2. Curvelet Transform

The curvelet transform (Jean-Luc Starck, *et al*, 2002), like the wavelet transform, is a multi scale transform, with frame elements indexed by scale and location parameters. Unlike the wavelet transform, it has directional parameters, and the curvelet pyramid contains elements with a very high degree of directional specialty. In addition, the curve-let transform is based on a certain anisotropic scaling principle which is quite different from the isotropic scaling of wavelets. Transfer function of curvelet transform is shown in equation (2).

$$\left\|f - \check{f}_m\right\|_2^2 = O(m^{-2}log^3 m) \cong O(m^{-2}) \quad (2)$$

where f is the given input image and m is the large coefficients of the given image. The curvelet transform include four stages

1. Sub-band decomposition: In sub-band decomposition the image f is decomposed into p_0, Δ_1, Δ_2.

$$f \rightarrow (P_0 f, \Delta_1 f, \Delta_2 f, ..) \quad (3)$$

where $P_0 \rightarrow$ low pass filter, Δ_1 and $\Delta_2 \rightarrow$ high pass filters.
2. Smooth partitioning: It produces a smooth dissection of the function into images by multiplying the high frequency image $\Delta_s f$ with the window function *W*.
3. Renormalization: It is the process of centering the dyadic square into unit square [0, 1]*[0, 1].
4. Ridgelet analysis: Each normalized square is analysed in the ridgelet transform (Minh and Martin, 2003).

Curvelets are an appropriate basis for representing images which is smooth apart from singularities along smooth curves, where the curves have bounded curvature, i.e. where objects in the image have a minimum length scale. Fig. 4. shows the curvelet transferred image.

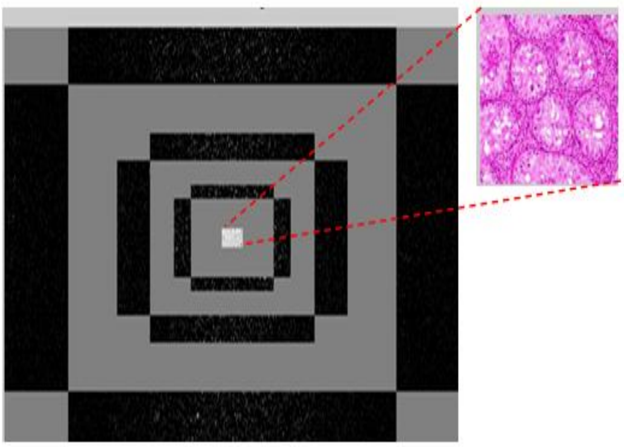


Fig. 4 Curvelet Transform Image

5. Similarity Matching

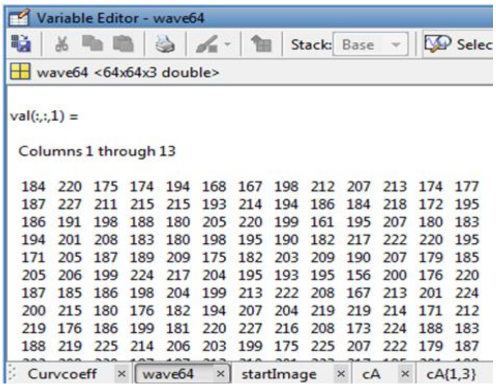
In CBIR, similarity matching is used to calculate the difference between two images. The proposed method Euclidean distance matching function is used for calculating distance between two points. Euclidean distance is shown in equation (4).

$$d(x, y) = \sqrt{\textstyle\sum_{i=0}^{n}(x - y)^2} \quad (4)$$

where x and y are the extracted features for the input image and the retrieved image simultaneously.

4. Experimental Results

The proposed method has two types of datasets in which the dataset1 contains 100 histology images and dataset2 contains 25 car images.



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Columns 1 through 13

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187	227	211	215	215	193	214	194	186	184	218	172	195
186	191	198	188	180	205	220	199	161	195	207	180	183
194	201	208	183	180	198	195	190	182	217	222	220	195
171	205	187	189	209	175	182	203	209	190	207	179	185
205	206	199	224	217	204	195	193	195	156	200	176	220
187	185	186	198	204	199	213	222	208	167	213	201	224
200	215	180	176	182	194	207	204	219	219	214	171	212
219	176	186	199	181	220	227	216	208	173	224	188	183
188	219	225	214	206	203	199	175	225	207	222	179	187

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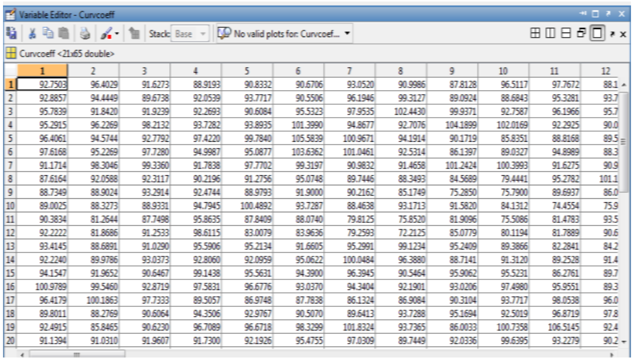
Fig. 5 DWT coefficients



Variable Editor - Curvcoeff

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Curvcoeff <21x65 double>

	1	2	3	4	5	6	7	8	9	10	11	12
1	92.7503	96.4029	91.6273	88.9193	90.8332	90.6706	93.0520	90.9986	87.8128	96.5117	97.7672	88.1
2	92.8857	94.4449	89.6738	92.0539	93.7717	90.5506	96.1946	99.3127	89.0924	88.6843	95.3281	93.7
3	95.7839	91.8420	91.9239	92.2693	90.6084	95.5323	97.9535	102.4430	99.9371	92.7587	96.1966	95.7
4	95.2915	96.2269	98.2132	93.7282	93.8935	101.3990	94.8677	92.7076	104.1899	102.0169	92.2925	90.0
5	96.4061	94.5744	92.7792	97.4220	99.7840	105.5839	100.9671	94.1914	90.1719	85.8351	88.8168	89.5
6	97.6168	95.2269	97.7280	94.9987	95.0877	103.6362	101.0461	92.5314	86.1397	89.0327	94.8989	88.3
7	91.1714	98.3046	99.3360	91.7838	97.7702	99.3197	90.9832	91.4658	101.2424	100.3993	91.6275	90.9
8	87.6164	92.0588	92.3117	90.2196	91.2756	95.0748	89.7446	88.3493	84.5689	79.4441	95.2782	101.1
9	88.7349	88.9024	93.2914	92.4744	88.9793	91.9000	90.2162	85.1749	75.2850	75.7900	89.6937	86.0
10	89.0025	88.3273	88.9331	94.7945	100.4892	93.7287	88.4638	93.1713	91.5820	84.1312	74.4554	75.9
11	90.3834	81.2644	87.7498	95.8635	87.8409	88.0740	79.8125	75.8520	81.9096	75.5086	81.4783	93.5
12	92.2222	81.8686	91.2533	98.6115	83.0079	83.9636	79.2593	72.2125	85.0779	80.1194	81.7889	90.6
13	93.4145	88.6891	91.0290	95.5906	95.2134	91.6605	95.2991	99.1234	95.2409	89.3866	82.2841	84.2
14	92.2240	89.9786	93.0373	92.8060	92.0959	95.0622	100.0484	96.3880	88.7141	91.3120	89.2528	91.4
15	94.1547	91.9652	90.6467	99.1438	95.5631	94.3900	96.3945	90.5464	95.9062	95.5231	86.2761	89.7
16	100.9789	99.5460	92.8719	97.5831	96.6776	93.0370	94.3404	92.1901	93.0206	97.4980	95.9551	89.3
17	96.4179	100.1863	97.7333	89.5057	86.9748	87.7838	86.1324	86.9084	90.3104	93.7717	98.0538	96.0
18	89.8011	88.2769	90.6064	94.3506	92.9767	90.5070	89.6413	93.7288	95.1694	92.5019	96.8719	97.8
19	92.4915	85.8465	90.6230	96.7089	96.6718	98.3299	101.8324	93.7365	86.0033	100.7358	106.5145	92.4
20	91.1394	91.0310	91.9607	91.7300	92.1926	95.4755	97.0309	89.7449	92.0336	99.6395	93.2279	90.2

Fig. 6 Curvelet coefficients

Fig. 7. a. Retrieved image using wavelet transforms

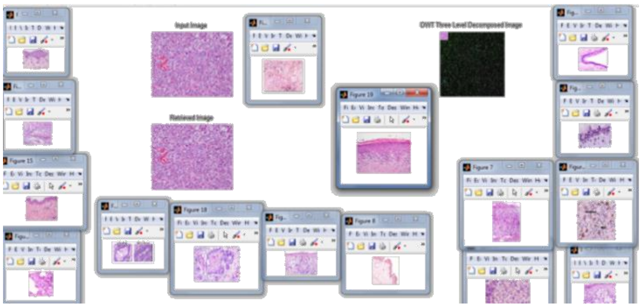

Fig.7. b. Retrieve Histology image using wavelet transforms

Histology means that is a fundamental tool that provides information on structure and composition of tissues at microscopic level. The database contains the query image and their extracted feature values (i.e. Coefficient of variations). Each image in the database used as a query image, according with the query image coefficient of variations and database values Euclidean distance is computed.

$$Precision = \frac{relevant\ retrieved}{all\ retrieved} \quad (5)$$

$$Recall = \frac{relevant\ retrieved}{all\ relevant} \quad (6)$$

The results are considered to be better if average values of precision and recall are high. Fig.9 shows the performance of wavelet and curvelet transforms, the performance analyzed was calculated using average precision and recall.

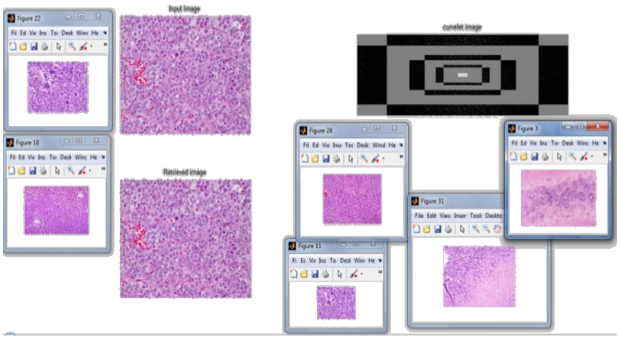

Fig 8. a. Retrieved image using curvelet transforms

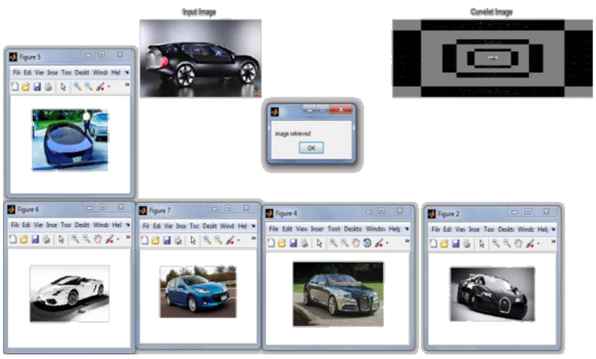

Fig. 8. b. Retrieved image using curvelet transform

Fig. 5. and Fig. 6. shows the decomposed coefficients of DWT and curvelet transforms. If the Euclidean distance is zero output is exactly matched according with the query image and the distance is less than 0.05 relevant images are retrieved. The Output of the wavelet based image retrieval is shown in Fig. 7. a. and Fig 7. b.

The result of Curvelet is shown in Fig. 8. a. and Fig. 8. b. The performance of the proposed method is measured is measured in terms of average precision and recall.

Table 1 Retrieval Evolution of the Proposed Results

Recall Percentage	Precision	
	Discrete Curvelet Transform	Discrete Wavelet Transform
0	0.79900	0.70000
0.1	0.72000	0.63339
0.2	0.67600	0.57311
0.3	0.60100	0.51857
0.4	0.53003	0.46922
0.5	0.49102	0.42457
0.6	0.43217	0.38417
0.7	0.392000	0.34761
0.8	0.35131	0.31453
0.9	0.32192	0.28460
1	0.29140	0.25752

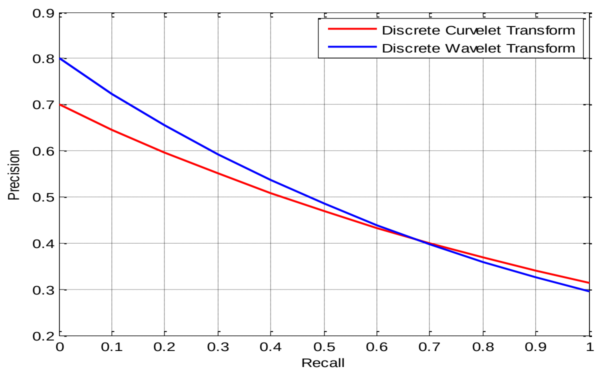

Fig. 9 Performance of DWT and Curvelet Transform in CBIR

Table 1 shows a mean retrieval performance across the histology images. Comparing the wavelet and curvelet based methods the curvelet transforms gives the best recall result. Our future work will include studying the weight selection scheme's performance and developing it into a big amount image database indexing scheme.

5. Conclusion

The goal of any information retrieval system is to retrieve documents that match the information needed by the user. But it is very difficult to specify the information needed to the CBIR system. Sometimes, even the users don't know their information needed precisely. Features are classified into two types: low-level and high-level features. The low-level features, such as a color histogram, are the features that can be extracted from raw multimedia data by a mathematical computation, such as image processing algorithms. On the other hand, the high-level features, such as the characteristics of a human face, cannot be readily and efficiently extracted through the use of a mathematical model. The proposed method retrieves the image effectively and the performance analysis shows it is well suitable for the histology image retrieval.

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