Local Wavelet Pattern: A New Feature Descriptor for Image Retrieval in Medical CT Databases

IEEE Transactions on Image Processing, 2015

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Introduction

- The existing local descriptors used the relationship of center pixel with its neighboring pixels and missed to utilize the inter-neighbor relationship.
- Proposed local wavelet pattern (LWP) utilized the inter-neighbor relationship using 1-D haar wavelet decomposition.
- The dimension of other methods increases significantly, whereas, the dimension of LWP is same as of the state-of-the-art local binary pattern (LBP) [1].
- The performance of LWP is promising over medical CT databases in image retrieval framework.

Medical CT Image Retrieval Framework using LWP

The medical CT image retrieval using proposed local wavelet pattern (LWP) is shown in Fig.1. Local neighborhood extraction, local wavelet decomposition, centre pixel transformation, local wavelet pattern generation, feature vector generation, similarity measurement, and image retrieval are the main processing units of the proposed CT image retrieval. Fig.2. shows the local neighbors of any center pixel.

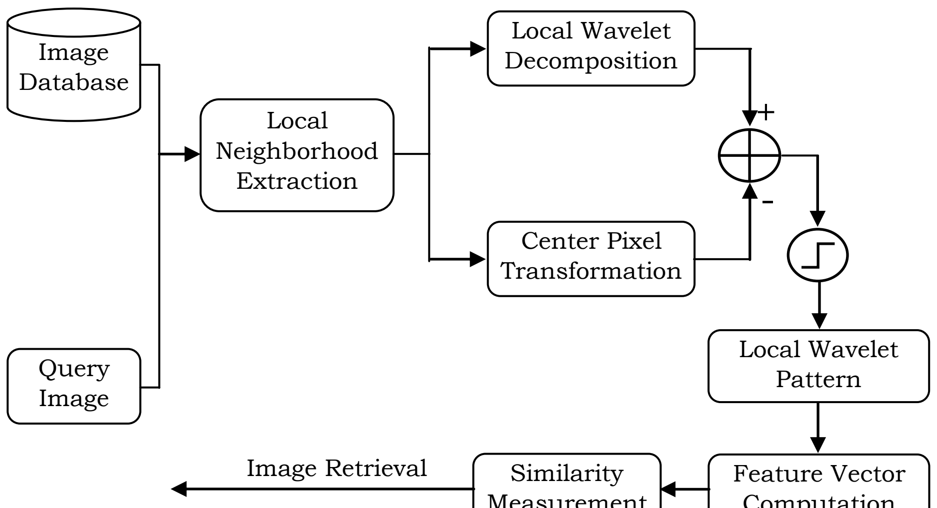

Fig.1. Proposed framework of medical CT image retrieval using LWP.

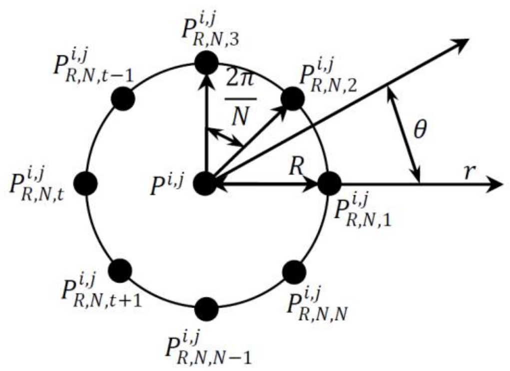

Fig.2. The local neighbors (i.e. $P^{i,j}_{R,N,t}$ for $\forall\, t \in [1,N]$) of a centre pixel ($P^{i,j}$).

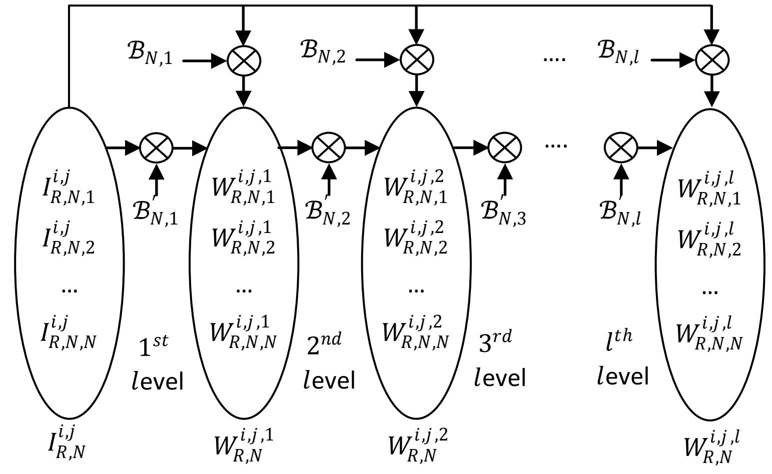

Fig.3. The wavelet decomposition of a vector $I^{i,j}_{R,N}$ into another vector $W^{i,j,l}_{R,N}$ using 1-D Haar wavelet at l^{th} level.

The 1-D Haar wavelet is used to decompose the local neighbors in order to encode the relationship among neighbors as shown in Fig.3. The $W^{i,j,l}_{R,N}$ is computed as follows,

$$W^{i,j,l}_{R,N} = \left(\mathcal{B}_{N,l} \times (I^{i,j}_{R,N})^T\right)^T \qquad (1)$$

where $\mathcal{B}_{N,l}$ is the basis function at l^{th} level for N values and given as follows,

$$\mathcal{B}_{N,l} = \begin{cases} \mathcal{B}'_{N,l} \times \mathcal{B}_{N,l-1} & If\ 1 \le l \le l_{max} \\ U_N & If\ l = 0 \end{cases} \qquad (2)$$

where U_N is the unit matrix of size $N \times N$, $\mathcal{B}_{N,l-1}$ is the basis function at $(l-1)^{th}$ level and $\mathcal{B}'_{N,l}$ is the 1-D Haar wavelet square basis matrix of size $N \times N$ for l^{th} level transformation. The values of the elements of matrix $\mathcal{B}'_{N,l}$ depends upon the level of transformation (i.e. l) and defined as follows,

$$\mathcal{B}'_{N,l}(u,v) = \begin{cases} \frac{1}{\sqrt{2}} & If\ (C_1\ and\ C_2)\ or\ (C_3\ and\ C_4) \\ -\frac{1}{\sqrt{2}} & If\ C_3\ and\ C_5 \\ 1 & If\ C_6 \\ 0 & Else \end{cases} \qquad (3)$$

where u and v are the row and column number of the matrix $\mathcal{B}'_{N,l}$ (i.e. $u \in [1,N]$ and $v \in [1,N]$) and C_γ are the different conditions for $\gamma = 1,2,\dots,6$ and defined as follows , $C_1 \rightarrow 1 \le u \le \frac{N}{2^l}$, $C_2 \rightarrow (v = 2u - 1)\ or\ (v = 2u)$, $C_3 \rightarrow \frac{N}{2^l} + 1 \le u \le \frac{N}{2^{l-1}}$, $C_4 \rightarrow v = 2u - \frac{N}{2^{l-1}} - 1$, $C_5 \rightarrow v = 2u - \frac{N}{2^{l-1}}$, and $C_6 \rightarrow \left(u \ge \frac{N}{2^{l-1}} + 1\right)\ and\ (v = u)$.

The value of center pixel is transformed into the range of decomposed neighboring values and compared similar to LBP and finally by taking the histogram over while image LWP feature vector is computed.

Experiments and Comparisons

The 8 local neighbors (N) at a radius (R) of 1 are used at 2nd level of wavelet decomposition to construct the LWP feature vector. The results of LWP are compared with the results of local binary pattern (LBP) [1], local ternary pattern (LTP) [2], local derivative pattern (LDP) [3], local mesh pattern (LMeP) [4], local ternary co-occurrence pattern (LTCoP) [5], local tetra pattern (LTrP) [6] and spherical-symmetric 3-D local ternary pattern (SS-3D-LTP) [7] feature vectors. The image retrieval results over three medical CT databases namely TCIA-CT [8] and EXACT09-CT [9] in terms of the average retrieval precision (ARP) are illustrated in Fig.4. Table 1 listed the ARP values for 10 retrieved images over TCIA-CT and EXACT09-CT databases. The LWP descriptor outperforms the state-of-the-art descriptors.

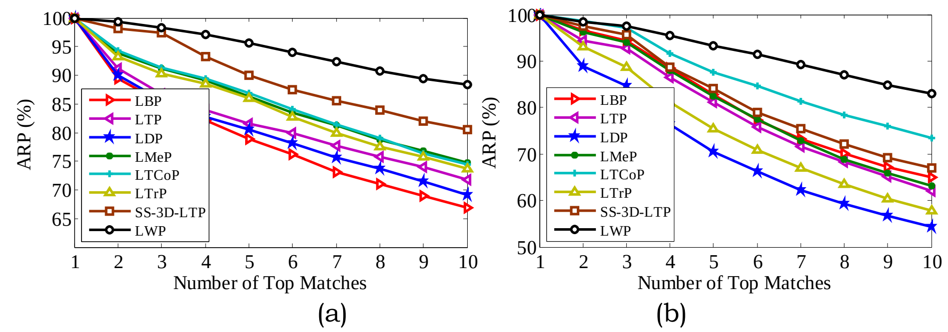

Fig.4. The retrieval results over (a) TCIA-CT and (b) EXACT09-CT databases in terms of ARP vs Number of Top Matches.

Table.1. Performance comparison of the descriptors using ARP values over different databases for 10 retrieved images.

Database	Method							
	LBP	LTP	LDP	LMeP	LTCoP	LTrP	SS-3D-LTP	LWP
TCIA-CT	66.91	71.83	69.06	74.69	74.40	73.71	80.54	88.42
EXACT09-CT	65.03	62.09	54.40	63.23	73.48	57.82	67.00	83.00

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