Local Diagonal Extrema Pattern: A New and Efficient Feature Descriptor for CT Image Retrieval

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Introduction

- The major problems with the existing descriptors are, 1) discriminative descriptors are high dimensional and 2) low dimensional descriptors are less discriminative.
- Local Diagonal Extrema Pattern (LDEP) uses the relationship among local neighbors as well as relationship of center with local neighbors.
- The consideration of only diagonal neighbors greatly reduces the dimension of the feature vector.
- The superiority in terms of performance and efficiency in terms of speedup of the proposed method are confirmed by the experiments over two CT image databases.

Local Diagonal Extrema Pattern

- The relationship of local diagonal extremes (i.e. maxima and minima) with the center pixel is used to encode the LDEP descriptor.
- The computation process of LDEP is illustrated using an example in Fig. 1.
- Fig. 1(a) shows the position of four diagonal neighbors with intensity values $I_1^{i,j}$, $I_2^{i,j}$, $I_3^{i,j}$ and $I_4^{i,j}$ of center with intensity value $I^{i,j}$.
- The example considered is depicted in Fig. 1(b).
- Let τ_{max} and τ_{min} are the position of maximum and minimum diagonal neighbors.
- The values of maximum and minimum diagonal neighbors (i.e. $I_{\tau_{max}}^{i,j}$ and $I_{\tau_{min}}^{i,j}$ respectively) as well as center pixel are extracted in Fig. 1(c).
- The values of τ_{max} and τ_{min} are shown in Fig. 1(d).

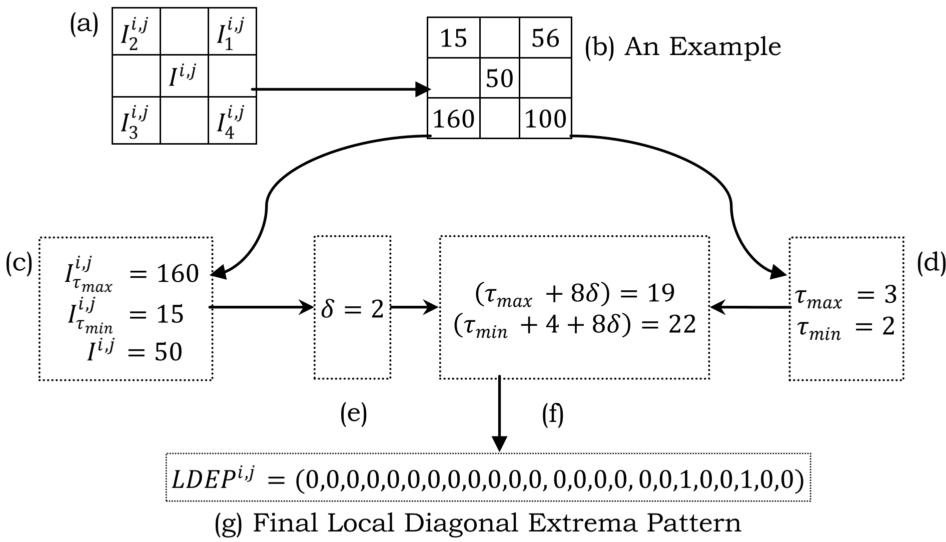

Fig.1. The computation of $LDEP^{i,j}$ pattern for center $I^{i,j}$ using the flow diagram with an example.

- The values and indexes of the local diagonal extremes are computed which is used with the central pixel to form the local diagonal extrema pattern.
- The local diagonal extrema pattern (LDEP) for $P^{i,j}$ is represented as a binary pattern $LDEP^{i,j}$ as follows,

$$LDEP^{i,j} = (LDEP_1^{i,j}, LDEP_2^{i,j}, \dots, LDEP_{dim}^{i,j}) \quad (1)$$

where dim is the length of the $LDEP$ pattern and $LDEP_k^{i,j}$ is the k^{th} element of the $LDEP^{i,j}$ and given using following formulae,

$$LDEP_k^{i,j}|_{k\in[1,dim]} = \begin{cases} 1, & if\ k = (\tau_{max} + 8\delta) \\ & or\ k = (\tau_{min} + 4 + 8\delta) \\ 0, & Else \end{cases} \quad (2)$$

where δ is defined as,

$$\delta = \begin{cases} 0, & If\ (I_{\tau_{max}}^{i,j} < I^{i,j}\ and\ I_{\tau_{min}}^{i,j} < I^{i,j}) \\ 1, & If\ (I_{\tau_{max}}^{i,j} \ge I^{i,j}\ and\ I_{\tau_{min}}^{i,j} \ge I^{i,j}) \\ 2, & Else \end{cases} \quad (3)$$

- Note that the dimension of the pattern $LDEP^{i,j}$ is the maximum possible value of k which is 24 when $\tau_{min} = 4$ and $\delta = 2$. It means that the dimension dim of the $LDEP^{i,j}$ is 24.
- The value of δ for considered example is demonstrated in the Fig. 1(e).
- Fig. 1(f) shows the values of $(\tau_{max} + 8\delta)$ and $(\tau_{min} + 4 + 8\delta)$.
- Finally, the LDEP pattern is depicted in Fig. 1(g). Only two elements of the pattern are set to 1 and the rest are zeros.

Experiments and Results

Databases Used –

Emphysema-CT [1]: Three categories Normal Tissue (NT), Centrilobular Emphysema (CLE), and Paraseptal Emphysema (PSE) containing 59, 50 and 59 images respectively.

NEMA-CT [2]: The 499 CT images from different parts of the body are collected from National Electrical Manufacturers Association (NEMA) and categorized into 8 categories having 104, 46, 29, 71, 108, 39, 33 and 69 images.

Descriptors Compared –

Local Binary Pattern (LBP) [3], Local Ternary Pattern (LTP) [4], Center Symmetric LBP (CSLBP) [5],Center Symmetric LTP (CSLTP) [6], Local Mesh Pattern (LMeP) [7], and Local Ternary Co-occurrence Pattern (LTCoP) [8].

Results –

The retrieval results are reported in terms of average retrieval precision (ARP), average retrieval rate (ARR), F-score, and total retrieval time in seconds. Fig. 2 illustrates the comparison results over Emphysema-CT database. Fig. 3 depicts the retrieval results over NEMA-CT database. The proposed descriptor is having the comparable performance with best one while maintaining very less retrieval time.

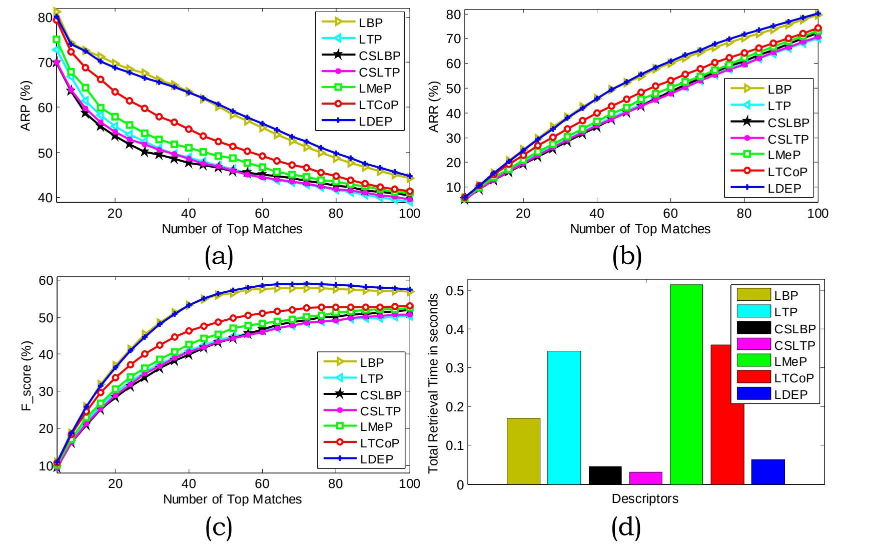

Fig.2. Comparison of (a) ARP (%), (b) ARR (%), (c) F_score (%), and (d) total retrieval time in seconds using LBP, LTP, CSLBP, CSLTP, LMeP, LTCoP and LDEP descriptors over Emphysema-CT database.

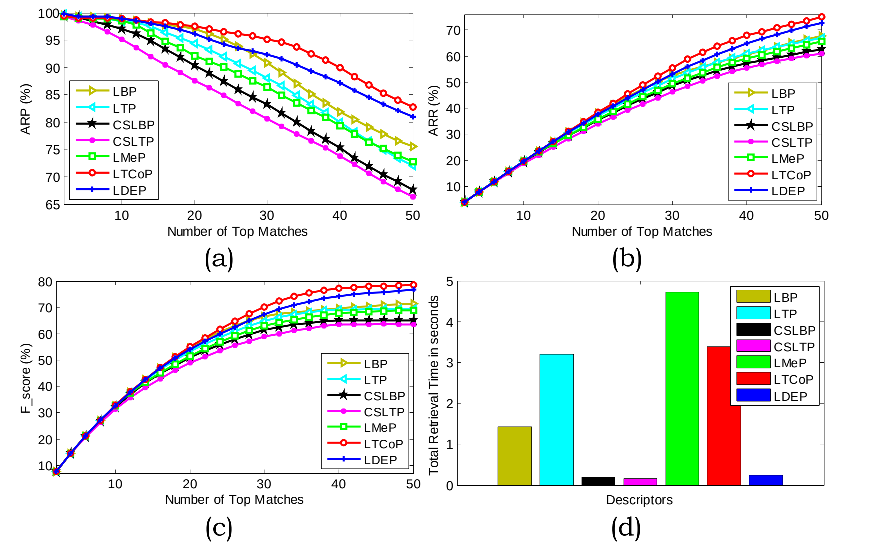

Fig.3. Comparison of (a) ARP (%), (b) ARR (%), (c) F_score (%), and (d) total retrieval time in seconds using LBP, LTP, CSLBP, CSLTP, LMeP, LTCoP and LDEP descriptor over NEMA-CT database.

References

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