A Novel Local Bit-plane Dissimilarity Pattern for CT Image Retrieval

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Introduction

- The recently proposed descriptors mainly suffer due to the “less discriminative power” and “high dimensionality”.
- A dissimilarity map is computed by encoding the dissimilarity between center and its neighbors over each Bit-plane.
- The relation between center and dissimilarity map is utilized to form the local bit-plane dissimilarity pattern (LBDISP).
- The dimension of LBDISP depends upon the number of neighbors only and same to the local binary patter (LBP) [1].
- A retrieval experiment over NEMA-CT database confirms the superiority and efficiency of LBDISP descriptor.

Local Bit-plane Dissimilarity Pattern

- Let $M^{i,j}$ is a pixel with intensity value $I^{i,j}$ in i^{th} row and j^{th} column of any image M (having B bit-depth) of dimension $m_1 \times m_2$.

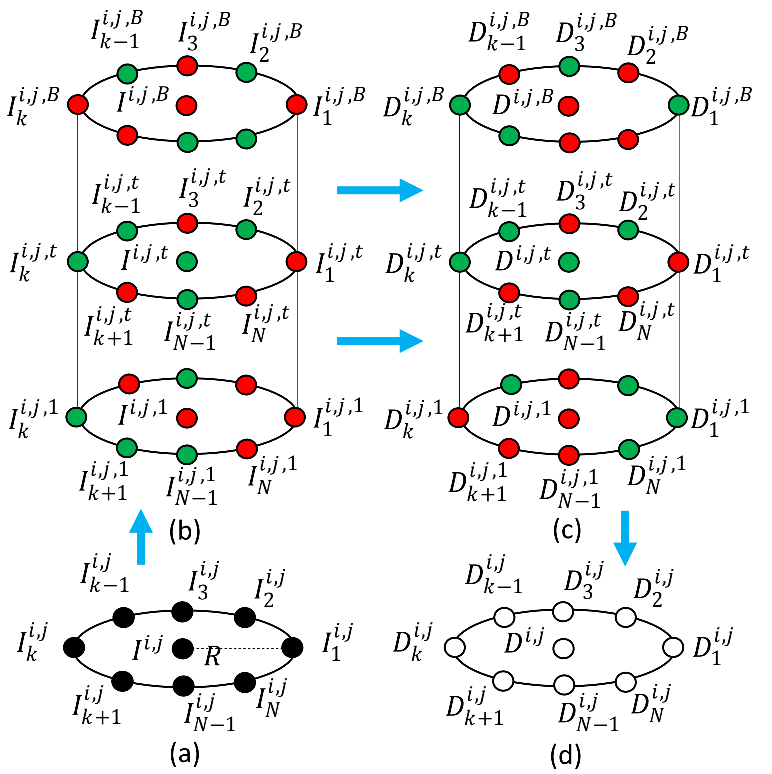

Fig.1. The local bit-plane decomposition and dissimilarity map generation, (a) a center pixel $M^{i,j}$ having intensity value $I^{i,j}$ and its N neighbors $M_k^{i,j}$ with intensity values $I_k^{i,j}|_{k\in[1,N]}$ situated at a radius of R at equal intervals, (b) the B bit-planes obtained after the local bit-plane decomposition, (c) the dissimilarity values of the neighbors at each bit-plane (the dissimilarity values for the center is unchanged), and (d) the local bit-plane dissimilarity map obtained by converting the bit-planes into the decimal. Note that ‘Black’ circles denotes the raw intensity values, ‘Red’ and ‘Green’ circles represent the binary bit ‘1’ and ‘0’ respectively, and ‘White’ circles signifies the dissimilarity values in decimal.

- The N neighbors of pixel $M^{i,j}$ equally spaced at a radius of R is represented by $M_k^{i,j}$ with intensity values $I_k^{i,j}$ for $k \in [1, N]$.
- The center pixel $M^{i,j}$ along with its N neighbors $M_k^{i,j}$ are decomposed into the B number of binary bits.
- The B bits of center pixel and its neighbors can be visualized as the B bit-planes of a cylinder as depicted in the Fig. 1(a-b).
- The $I^{i,j,t}$ is the binary bit in t^{th} bit-plane corresponding to the raw intensity value $I^{i,j}$, and similarly $I_k^{i,j,t}$ is the binary bit in t^{th} bit-plane corresponding to the $I_k^{i,j}$ (i.e. k^{th} neighbor of center pixel) for $t \in [1, B]$.
- The local bit-plane dissimilarity basically encodes the difference between the center and its neighbors at each bit-plane as depicted in Fig. 1(c).
- Let $D_k^{i,j,t}$ is the binary value obtained after local bit-plane dissimilarity encoding in t^{th} bit-plane for a k^{th} neighbor of the center pixel. The $D_k^{i,j,t}$ is computed as:

$$D_k^{i,j,t}|_{t\in[1,B]\,\&\,k\in[1,N]} = \begin{cases} 0, & if\ I_k^{i,j,t} = I^{i,j,t} \\ 1, & otherwise \end{cases} \quad (1)$$

Note that this step does not affect the binary values $I^{i,j,t}$. In other words, $D^{i,j,t} = I^{i,j,t}$ for $t \in [1, B]$ or $D^{i,j} = I^{i,j}$.

- The N neighboring values in local bit-plane dissimilarity map is represented with $D_k^{i,j}$ (see Fig. 1(d)) and computed as:

$$D_k^{i,j}|_{k\in[1,N]} = \sum_{t=1}^{B} 2^{t-1} \times D_k^{i,j,t} \quad (2)$$

- The LBDISP feature vector is calculated as follows,

$$H(k) = \sum_{i=R+1}^{m_1-R} \sum_{j=R+1}^{m_2-R} \begin{cases} 1, & if\ \gamma = \sum_{k=1}^{N} 2^{k-1} \times LBDISP_k^{i,j} \\ 0, & Otherwise \end{cases} \quad (3)$$

for $\forall\, \gamma \in [1, 2^N - 1]$, where $LBDISP_k^{i,j}$ is the k^{th} element of $LBDISP^{i,j}$ and represents the relationship between the center and k^{th} neighbor of the dissimilarity map as follows,

$$LBDISP_k^{i,j}|_{k\in[1,N]} = \begin{cases} 1, & if\ D_k^{i,j} \geq D^{i,j} \\ 0, & otherwise \end{cases} \quad (4)$$

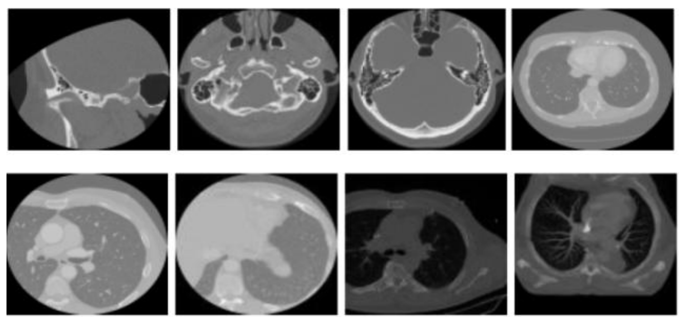

Fig.2. Sample images from NEMA-CT database (one image per category).

Experiments and Results

- NEMA-CT database [2] is used for the retrieval experiment. This database is consists of 499 CT images from different body parts categorized into 8 categories having 104, 46, 29, 71, 108, 39, 33 and 69 images respectively. The example images of this database are shown in Fig. 2.
- The LBDISP is compared with the Local Binary Pattern (LBP) [1], Local Ternary Pattern (LTP) [3], Local Derivative Pattern (LDP) [4], Local Tetra Pattern (LTrP) [5], Local Ternary Co-occurrence Pattern (LTCoP) [6], Local Mesh Pattern (LMeP) [7], Local Diagonal Extrema Pattern (LDEP) [8], and Local Bit-plane Decoded Pattern (LBDP) [9].
- The values of R, N, and B are 1, 8, and 8 respectively.
- The D_1 similarity measure is used [6].
- The average retrieval precision (ARP) and average normalized modified retrieval rank (ANMRR) over NEMA-CT database is depicted in Fig. 3 using different descriptors. High value of ARP and low value of ANMRR signifies the better retrieval performance and vice-versa.
- The LBDP descriptor outperforms the state-of-the-art descriptors over NEMA-CT database.

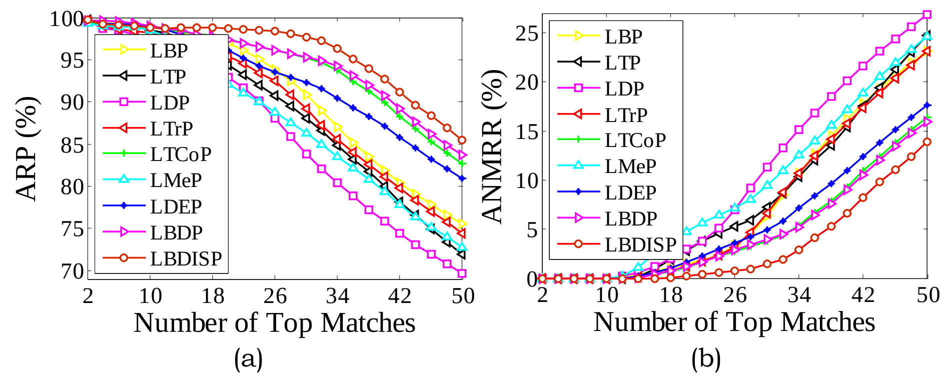

Fig.3. The experimental results over NEMA-CT database for each descriptor using (a) ARP and (b) ANMRR evaluation measure.

References

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