Introduction

- Local Bit-plane Decoded Pattern (LBDP) encodes the local information in two ways, 1) relationship among the local neighbors at each bit-plane and 2) relationship of center with its neighbors.
- The dimension of other methods increases significantly while trying to enhance the discriminative ability, whereas, the dimension of LBDP is same to the Local Binary Pattern (LBP).
- The improved performance is observed over one MRI and two CT databases.

Local Bit-plane Decoded Pattern

Let $M$ is a image of dimension $m_1 \times m_2$, with bit depth of $B$-bit. The $P_{i,j}^k$ is a pixel at coordinate $(i,j)$ with intensity value $I_{i,j}^k$. The $N$ local neighbors of $P_{i,j}^k$ at a circle of radius $R$ are represented by $P_{i,r}^k$. The $T$-th neighbor of $P_{i,j}^k$ is denoted as $P_{i,r}^k$ having intensity value $I_{i,r}^k$, where $r \in [1, N]$. The binary value $I_{i,j}^{k,j}$ of the $T$-th neighbor of $P_{i,j}^k$ in $k$th bit-plane is defined as follows,

$$I_{i,j}^{k,j} = \begin{cases} 1, & \text{if } k = 1 \\ f_k = \frac{I_{i,j}^k - I_{i,r}^k}{2}, & \text{otherwise} \end{cases} \quad (1)$$

Fig. 2 shows the LBP map [1] and local bit-plane transformed value maps for a sample image from OASIS-MRI database [2]. The LBDP pattern for pixel $P_{i,j}^k$ is given as follows,

$$LBDP_{i,j}^k = (LBDP_{1,R}^{1,j}, LBDP_{1,R}^{2,j}, \ldots, LBDP_{B,R}^{1,j})$$

where $LBDP_{i,j}^k$ is a binary value computed over $k$th bit-plane as,

$$LBDP_{i,j}^k = \begin{cases} 1, & \text{if } v_{i,j}^k > 1 \\ 0, & \text{Otherwise} \end{cases} \quad (4)$$

where $k \in [1,B]$ and $v_{i,j}^k$ is a value obtained after range matching of $I_{i,j}^k$ with the range center value and defined as follows,

$$v_{i,j}^k = \frac{I_{i,j}^k + 1}{2^{(B-k)}} - 1 \quad (5)$$

Finally, the histogram over whole image is computed to find the LBDP descriptor over that image.

Experiments and Results

**Databases Used**

Empysema-CT [3]: Three categories containing 59, 50 and 59 CT images respectively. NEMA-CT [4]: The 499 CT images categorized into 8 categories having 104, 46, 29, 71, 108, 39, 33 and 69 images. OASIS-MRI [2]: Total 421 images from four categories having 106, 89, 102 and 124 images.

**Descriptors Compared**

Local binary pattern (LBP) [1], Local ternary pattern (LTP) [5], Peak valley edge pattern (PVEP) [6], Local mesh pattern (LMeP) [7], and Local ternary co-occurrence pattern (LTCoP) [8].

The retrieval results are reported in terms of average retrieval precision (ARP). Fig. 3 illustrates the comparison results over Empysema-CT, NEMA-CT and OASIS-MRI databases. The total retrieval time in seconds is depicted in Table 1. It is generated using MATLAB software over a computer having Intel(R) Core(TM) i5 CPU 650g/3.20 GHz processor, 4 GB RAM, and 32-bit Windows 7 Ultimate operating system. The proposed LBDP descriptor outperforms the state-of-the-art descriptors while maintaining very less retrieval time.

**Fig. 2.** Example of local bit-plane transformed values map for each bit-planes for $N = 8$ and $B = k$, (a) sample image, (b) LBP map [1] over (a), (c-j) local bit-plane transformed value maps for each bit-plane. **Fig. 3.** Result over (a) Empysema-CT, (b) NEMA-CT, and (c) OASIS-MRI databases using LBP, LTP, PVEP, LTCoP, LMeP, and LBDP descriptors.

Table 1. The total retrieval time in seconds over Empysema-CT, NEMA-CT and OASIS-MRI databases using each descriptor.

<table>
<thead>
<tr>
<th>Database</th>
<th>LBP</th>
<th>LTP</th>
<th>PVEP</th>
<th>LTCoP</th>
<th>LMeP</th>
<th>LBDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empysema-CT</td>
<td>0.07</td>
<td>0.11</td>
<td>0.85</td>
<td>0.14</td>
<td>0.14</td>
<td>0.06</td>
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<td>NEMA-CT</td>
<td>0.46</td>
<td>0.84</td>
<td>12.63</td>
<td>0.85</td>
<td>1.52</td>
<td>0.43</td>
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<tr>
<td>OASIS-MRI</td>
<td>0.34</td>
<td>0.58</td>
<td>9.56</td>
<td>0.61</td>
<td>1.42</td>
<td>0.33</td>
</tr>
</tbody>
</table>

**References**

4. NEMA-CT image database, [ftp://medical.nema.org/ medical/Dicom/Multiframe/].