CHAPTER - 7

MOMENTS CONCEPT AND VARIABLE SIZE RANGE BLOCK
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MOMENTS CONCEPT AND VARIABLE SIZE RANGE BLOCK

7.1 Moments Concept

The fractal image compression technique utilizing moment features based on the zero mean range improved by decrease the number of isometric trails. The moments are used to index each domain and range blocks onto one of eight possible isometric states. At each range domain the indices of both domain and range blocks are passed through the predictor, then the predictor outputs the index of the required isometric transform to get the best possible match between the domain and range blocks. The moment features used to accelerate the iterated function system matching stage. These features are used to focus the block descriptor moment ratio index which in turn is used to classify the image blocks in both domain and range pools. During the encoding stage the block moment ratio descriptor of each range blocks is used to filter the domain blocks and keep only those blocks whose moment descriptor [123] is suitable to be IFS matched with the tested range block. The results demonstrated a lower encoding time with good PSNR.

In context of Satellite images, the change in conditions is to be observed at different times. The fractal image compression algorithms have a common approach which involves the partitioning of the image into smaller non overlapping square subsections range blocks of variable size. Then, a search domain pool is created from the image taking all the domain blocks of size double of the range blocks and ultimately for each range block, the most appropriate domain block is selected from the domain pool. It is noted that transformations are required to be performed on the range block to match with the domain block. The decoding process involves the number iteration on the image. The local variance analysis for domain blocks and range blocks can be effectively used for speeding up the fractal compression. This algorithm results in fast search of domain blocks corresponding to range block. It is shown that the reduction of search CPU by several times can be provided depends upon the complexity of image to be compressed.
The procedure of speeding up the fractal compression does not result in additional losses in recovered image quality. The results show that the local variance analysis for domain blocks and range blocks can be effectively used for speeding up the fractal compression. Its application considerably accelerates the domain block search without loss in compressed image PSNR. The local variance computational does not require essential computational efforts [96].

In fractal image scheme compression using Variable size range block, the image is partitioned by considering maximum and minimum size of the range block and also computing moment of range and domain block to improve the quality of the image PSNR and CR values for the Lena and Satellite imageries.

The image f(x, y), x and y are the coordinates of (i, j) pixel. The range block with pixel values (r₀, r₁, ...........,rₙ₋₁) and the domain block (d₀,d₁,.....,dₙ₋₁), then for each domain block and range block determine its first order moments(Mₜ) and (Mᵣ) from the equations (7.1), (7.2), (7.3) and (7.4).

\[ M_d (1,0) = \sum_{j=0}^{k-1} \sum_{i=0}^{k-1} (x_i - k_c)(d_{ij} - d') \]  \hspace{1cm} (7.1)

\[ M_d (0,1) = \sum_{j=0}^{k-1} \sum_{i=0}^{k-1} (y_i - k_c)(d_{ij} - d') \]  \hspace{1cm} (7.2)

\[ M_r (1,0) = \sum_{j=0}^{k-1} \sum_{i=0}^{k-1} (x_i - k_c)(r_{ij} - r') \]  \hspace{1cm} (7.3)

\[ M_r (0,1) = \sum_{j=0}^{k-1} \sum_{i=0}^{k-1} (y_i - k_c)(r_{ij} - r') \]  \hspace{1cm} (7.4)
Where \( d' = \frac{1}{m} \sum_{i=0}^{m-1} d_i \), \( r' = \frac{1}{m} \sum_{i=0}^{m-1} r_i \), ‘m’ is the mean and ‘k’ is the block length and \( k_c \) is the value of x and y coordinates of the center point is calculating as \( k_c = \frac{(k-1)}{2} \).

Calculating the moment ratio factors for domain (\( R_d \)) and range blocks (\( R_r \)) and index (\( I_d \)) from the equations (7.5) and (7.6),

\[
R_d = \frac{M_d^2 (O,1) - M_d^2 (1,O)}{M_d^2 (O,1) + M_d^2 (1,O)} \quad (7.5)
\]

\[
R_r = \frac{M_r^2 (O,1) - M_r^2 (1,O)}{M_r^2 (O,1) + M_r^2 (1,O)} \quad (7.6)
\]

Calculating the moment’s ratio index value ‘\( I_d \)’ and ‘\( I_r \)’ from the equations (7.7) and (7.8),

\[
I_d = round \left( |R_d| \times N_{max} \right) \quad (7.7)
\]

\[
I_r = round \left( |R_r| \times N_{max} \right) \quad (7.8)
\]

Where \( N_{max} \) is the maximum moment’s ratio index value.

### 7.2 The Encoding and Decoding Algorithm

- Partitioning the Variable size range block of three cases are (i) maximum range block size (\( R_{max} \)) = 16 to minimum range block size (\( R_{min} \)) = 4, case (ii) \( R_{max} = 16 \) to \( R_{min} = 8 \) and case (iii) \( R_{max} = 8 \) to \( R_{min} = 4 \) are compared with domain blocks.
- The domain block size of window KxK are sliding over the entire image in steps of K/2.

The pixels in the domain are averaged in groups so that the domain is reduced to the size of the range and applying Affine transformation.
• After partitioning and transformation, Construct the domain and range pool.
• For each domain block and range block compute its moments from the equations (7.1), (7.2), (7.3) and (7.4).
• Determining the moment’s ratio factors for domain and range blocks from the equations (7.5) and (7.6).
• Calculate moments ratio value from the equations (7.7) and (7.8).
• Mapping each range blocks to domain blocks and applying entropy coding to achieve fractal compression. Calculating the compression ratio (CR).
• Record the fractal decoder to reconstruct the image and calculating PSNR.

7.3 Results and Discussion

Using moments concept and Variable size range block for three cases (i) $R_{\text{max}} = 16$ to $R_{\text{min}} = 4$ case (ii) $R_{\text{max}} = 16$ to $R_{\text{min}} = 8$ and case (iii) $R_{\text{max}} = 8$ to $R_{\text{min}} = 4$, the imageries are subjected to fractal compression scheme. The CR and PSNR values are determined for the Lena image, Satellite Rural image and Satellite Urban imageries and displayed in Table 7.1.

Table 7.1: Using Moments Concept and Variable Size Range Block, the CR and PSNR Values Obtained for the Three Cases of Lena and Satellite Imageries.

<table>
<thead>
<tr>
<th>Range Block Size</th>
<th>Lena Image</th>
<th>Satellite Rural Image</th>
<th>Satellite Urban Image</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CR</td>
<td>PSNR(dB)</td>
<td>CR</td>
</tr>
<tr>
<td>$R_{\text{max}} = 16$</td>
<td>2.9</td>
<td>33.2</td>
<td>3.3</td>
</tr>
<tr>
<td>$R_{\text{min}} = 4$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{\text{max}} = 16$</td>
<td>12.4</td>
<td>32.6</td>
<td>13.7</td>
</tr>
<tr>
<td>$R_{\text{min}} = 8$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{\text{max}} = 8$</td>
<td>2.9</td>
<td>34.4</td>
<td>3.1</td>
</tr>
<tr>
<td>$R_{\text{min}} = 4$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Table 7.1 demonstrates that the CR and PSNR values derived for the Lena and Satellite imageries shows for case (i) where the Variable size range block $R_{\text{max}}=16$ to $R_{\text{min}}=4$ found that for the Lena image $CR \approx 2.9$, $\text{PSNR} \approx 33.2$ dB, the Satellite Rural image $CR \approx 3.3$, $\text{PSNR} \approx 30$ dB and for the Satellite Urban image $CR \approx 3.3$, $\text{PSNR} \approx 25.5$. The Variable size range block case (ii) $R_{\text{max}}=16$ to $R_{\text{min}}=8$ achieves higher CR values that is for the Lena image shows $CR \approx 12.4$, $\text{PSNR} \approx 32.6$ dB, the Satellite Rural image $CR \approx 13.7$, $\text{PSNR} \approx 28.5$ dB and for the Satellite Urban image $CR \approx 13.8$, $\text{PSNR} \approx 24.5$ dB. The Variable size range block case (iii) $R_{\text{max}}=8$ and $R_{\text{min}}=4$ found that higher PSNR of three types of imageries that is for the Lena image shows $CR \approx 2.9$, $\text{PSNR} \approx 34.4$ dB, the Satellite Rural image $CR \approx 3.1$, $\text{PSNR} \approx 31.8$ dB and for the Satellite Urban image $CR \approx 3.1$, $\text{PSNR} \approx 27.4$ dB.

The Moments concept and Variable size range block FIC scheme achieves very good compression parameters shows higher CR and PSNR values for the Lena and Satellite imageries. The results indicate maximum values for Variable size range block $R_{\text{max}}=16$ to $R_{\text{min}}=8$ (case ii) for the Lena image $CR \approx 12.4$, $\text{PSNR} \approx 32.6$ dB, for the Satellite Rural image $CR \approx 13.7$, $\text{PSNR} \approx 28.5$ dB and for the Satellite Urban image $CR \approx 13.8$, $\text{PSNR} \approx 24.5$ dB. This suggests that the moment based fractal image compression scheme using Variable size range block is very best suited for the compression of Satellite imageries. The quality of the reconstructed image is very high as the PSNR achieved is maximum for all three types of images.

Moment based Variable size range block FIC scheme depicts higher CR and PSNR performance efficiency for the Variable size range block $R_{\text{max}}=16$ to $R_{\text{min}}=8$ indicating $CR > 12.4$ and $\text{PSNR} > 24.5$ dB for all the three types of imageries.

Table 7.2 shows encoding and decoding time for the Variable size range block using moments concept for both Lena and Satellite imageries.
Table 7.2: The Encoding and Decoding Time for Lena and Satellite Imageries Using Moments and Variable Size Range Block.

<table>
<thead>
<tr>
<th>Test Images</th>
<th>Range Block Size</th>
<th>Time Taken for Encoding (Sec)</th>
<th>Time Taken for Decoding (Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lena Image</td>
<td>( R_{\text{max}} = 16, R_{\text{min}} = 4 )</td>
<td>744.0</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>( R_{\text{max}} = 16, R_{\text{min}} = 8 )</td>
<td>102.6</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>( R_{\text{max}} = 8, R_{\text{min}} = 4 )</td>
<td>912.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Satellite Rural Image</td>
<td>( R_{\text{max}} = 16, R_{\text{min}} = 4 )</td>
<td>158.4</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>( R_{\text{max}} = 16, R_{\text{min}} = 8 )</td>
<td>52.3</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>( R_{\text{max}} = 8, R_{\text{min}} = 4 )</td>
<td>658.1</td>
<td>0.09</td>
</tr>
<tr>
<td>Satellite Urban Image</td>
<td>( R_{\text{max}} = 16, R_{\text{min}} = 4 )</td>
<td>145.0</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>( R_{\text{max}} = 16, R_{\text{min}} = 8 )</td>
<td>49.8</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>( R_{\text{max}} = 8, R_{\text{min}} = 4 )</td>
<td>577.7</td>
<td>0.09</td>
</tr>
</tbody>
</table>

The Table 7.2 shows that the computational time for the Variable size range block \( R_{\text{max}} = 16 \) to \( R_{\text{min}} = 4 \) for all three types image shows encoding time <744 Sec and decoding time <0.3 Sec. The Variable size range block \( R_{\text{max}} = 16 \) to \( R_{\text{min}} = 8 \) for all three types image shows encoding time <103 Sec and decoding time <0.1 Sec, the Variable size range block \( R_{\text{max}} = 8 \) to \( R_{\text{min}} = 4 \) all three types image shows encoding time >577.7 Sec and decoding time <0.3 Sec.

This indicates less encoding and decoding time for the Variable size range block \( R_{\text{max}} = 16 \) to \( R_{\text{min}} = 8 \) for both Lena and Satellite imageries. Also for all three cases of range block size takes less encoding and decoding time.

The Lena and Satellite imageries reconstructed using moments concept and Variable size range block \( R_{\text{max}} = 16 \) to \( R_{\text{min}} = 8 \) are shown in Fig. 7.1, 7.2 and 7.3. For comparison the original image is also displayed in the same figure.
Fig.7.1: Lena Image Using Moments Concept and Variable Size Range Block for $R_{max} = 16$ to $R_{min} = 8$, CR $\sim 12.4$ and PSNR $\sim 32.6$ dB.

Fig.7.2: Satellite Rural Image Using Moments Concept and Variable Size Range Block for $R_{max} = 16$ to $R_{min} = 8$, CR $\sim 13.7$ and PSNR $\sim 28.5$ dB.
The Fig. 7.1, 7.2 and 7.3 evident that for the FIC scheme using moments concept and Variable size range block $R_{\text{max}} = 16$ to $R_{\text{min}} = 8$ achieves higher CR and PSNR for Lena and Satellite imageries. The Lena image CR $\approx 12.4$, PSNR $\approx 32.6$ dB, for the Satellite Rural image CR $\approx 13.7$, PSNR $\approx 28.5$ dB and for the Satellite Urban image CR $\approx 13.8$, PSNR $\approx 24.5$ dB.

From the FIC analysis carried out based on moments concept and Variable size range block, it can be concluded that the $R_{\text{max}} = 16$ to $R_{\text{min}} = 8$ shows superior performance by achieving higher CR and PSNR for all three imageries. The Lena image shows CR $\approx 12.4$, PSNR $\approx 32.6$ dB and for Satellite imageries CR $> 13.7$, PSNR $> 24.5$ dB. The encoding and decoding time is less for all three cases of Variable size range block. The result of the analysis suggest that FIC scheme using moments and Variable size range block can be used to achieve higher CR and PSNR values compared to other fractal image compression schemes such as Fixed size range block segmentation (Chapter 3), Quadtree decomposition (Chapter 4), Domain pool classification (Chapter 5) and Variable size range block (Chapter 6).

The work presented in this chapter has been published in the paper titled “Fractal Image Compression of Satellite Imageries Using Moments and Variable Size Range Blocks” International Conference on Communication and Computing (ICCC), Published in Elsevier, Bangalore, PP. 26 – 32, 21st to 23rd August 2014.
7.4 Moments Concept Extended to Fixed Size Range Block

The images divided into Fixed size range block 4x4, 8x8 and 16x16 are subjected to FIC using moment concept to encode and decode the images. The CR and PSNR values have been determined using moments and Fixed size range block for the Lena image, Satellite Rural image and Satellite Urban imageries are shown in Table 7.3.

**Table 7.3: The CR and PSNR Values Derived for the Fixed Size Range Block Using Moment Concept.**

<table>
<thead>
<tr>
<th>Fixed Range Block Size Using Moment Concept</th>
<th>Lena Image</th>
<th>Satellite Rural Image</th>
<th>Satellite Urban Image</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CR</td>
<td>PSNR (dB)</td>
<td>Time Taken for Encoding (Sec)</td>
</tr>
<tr>
<td>4x4</td>
<td>3.3</td>
<td>31.2</td>
<td>2341.7</td>
</tr>
<tr>
<td>8x8</td>
<td>14.5</td>
<td>27.6</td>
<td>234.8</td>
</tr>
<tr>
<td>16x16</td>
<td>63.4</td>
<td>24.7</td>
<td>26.1</td>
</tr>
</tbody>
</table>

The Table 7.3 the Fixed size range block 4x4 shows for the Lena image CR ~3.3, PSNR ~31.2 dB, for Satellite Rural image CR ~3.1, PSNR ~34.5 dB and Satellite Urban image CR ~3.0, PSNR ~30.7 dB. The Fixed size range block 8x8 shows for the Lena image CR ~14.5, PSNR ~27.6 dB, for Satellite Rural image CR ~13.6, PSNR ~29.4 dB and Satellite Urban image CR ~13.7, PSNR ~24.2 dB. The Fixed size range block 16x16 shows for the Lena image CR ~63.4, PSNR ~24.7 dB, for Satellite Rural image CR ~60.2, PSNR ~27.5 dB and Satellite Urban image CR ~62.3, PSNR ~22.2 dB.

The Table 7.3 depicts that for the Fixed size range block 4x4, all the three image shows good CR and PSNR values. Lena image CR ~3.3, PSNR ~31.2 dB, for Satellite Rural image CR ~3.1, PSNR ~34.5 dB and Satellite Urban image CR ~3.0, PSNR ~30.7 dB.

The Moments concept extended to Fixed size range block 4x4 though indicates lower CR but higher PSNR values for the three types of imageries.
The Table 7.3 also indicates that the computational time for the Fixed size range block 4x4 for three types image shows maximum encoding time >2267 Sec and decoding time ~0.1 Sec. The Fixed size range block 8x8 for three types image shows encoding time <235 Sec and decoding time ~0.06 Sec. The Fixed size range block 16x6 for three types image shows less encoding time < 26 Sec and decoding time ~0.05 Sec. It is found that the encoding – decoding time decreases as the range block size increases and for the Fixed size range block 4x4 the computational time is maximum.

The results clearly indicate that the FIC technique using moments concept for Fixed size range block 4x4 shows better quality of the reconstructed Lena and Satellite imageries with CR ~3.0 and PSNR >31 dB.

The CR and PSNR values obtained using moment concept based Variable size range block R_{max} = 16 to R_{min} = 8 FIC technique and moment based Fixed size range block 4x4 FIC technique are compared for the Lena and Satellite imageries are shown in the Table 7.4.

Table 7.4: The Comparisons of CR and PSNR values are Derived using Moment Concept Based Fixed Size Range Block with Variable Size Range Block.

<table>
<thead>
<tr>
<th>Range Block Size</th>
<th>Lena Image</th>
<th>Satellite Rural Image</th>
<th>Satellite Urban Image</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CR</td>
<td>PSNR (dB)</td>
<td>Time Taken for Encodin (Sec)</td>
</tr>
<tr>
<td>Fixed Size Range Block 4x4</td>
<td>3.3</td>
<td>31.2</td>
<td>2341.7</td>
</tr>
<tr>
<td>Variable Size Range Block R_{max} = 16 R_{min} = 8</td>
<td>12.4</td>
<td>32.6</td>
<td>102.6</td>
</tr>
</tbody>
</table>
The Table 7.4 that FIC using Moments concept with Fixed size range block 4x4 shows for the Lena image CR ~3.3, PSNR ~31.2 dB and for the Satellite imageries CR ~3.0, PSNR >31 dB Whereas the CR and PSNR values derived using Moments concept with Variable size range block R_{max} = 16 to R_{min} = 8 shows higher values of CR and PSNR, for the Lena CR ~12.4 and PSNR ~32.6 dB and for the Satellite imageries CR ~13.7 and PSNR > 24.5 dB compared to Fixed size range block approach. The time taken for encoding-decoding for Variable size range block is less compared to the Fixed size range block.

The results suggest that the FIC technique using Moments concept and Variable size range block are more efficient for achieving higher CR and PSNR values for Lena and Satellite imageries.

The work presented in this chapter has been published in the paper titled “Fractal Image Compression of Satellite imageries Using Fixed Range Block Based Segmentation and Moments”. Accepted in International Journal on Association of Computer Electronics and Electrical Engineers Signal Image Processing Application (ACEEE SIPA), 2014.