CHAPTER 4

LIFTING SCHEME BASED TWO DIMENSIONAL DISCRETE WAVELET TRANSFORM (2D-DWT)

In the Discrete Wavelet Transform, the bi-orthogonal wavelets are implemented by using the lifting method. The spatial domain and lifting procedure is used to build the lifting method. In the lifting scheme, three main steps are mainly performed that are, split, predict and update. The input image samples x(n) are divided regarding the odd and even samples in the split block. The filter is required for the odd and even samples to prevent from the unwanted signaling. Lifting scheme is performed by based type of the filter. Scaling step is used to find the low pass sub-bands of the odd and even samples. Filter implementations are transformed into the multiplication matrices in the lifting scheme. The image compression is performed efficiently by using the lifting plan, and the hardware utilizations are highly reduced by using the filters.

4.1 Performance of the Image Compression

Image Compression has turned into a dynamic zone of research about in the field of Image processing technique especially in the uses of medical and space applications. Many image compression methodologies are presented, yet at the same time there is need to develop faster, and stronger methodologies in the image compression techniques. The challenges in developing the advanced compression techniques are the requirement for saving the details i.e. edges endings and bifurcations, which are mainly used in identifications. To accomplish the efficient image compression while sharing this fine information, wavelet data are utilized. Nowadays, the transformation has developed as a cutting edge technology, in the field of image compression.
The discrete wavelet change has ended up being one of the most utilized methods for image coding and image compression techniques. For example, the JPEG 2000 standard. The coding capability and the image quality storage with the DWT are predominant than those with the conventional discrete cosine transform. The performance of one dimensional discrete wavelet transforms (1-D DWT) by filters has been offered. This method, implies (9/7) lifting channel. The primary concentrate is on the equipment execution of the lifting filter as utilized for two dimensional discrete wavelet transform. In this 2D-DWT lifting based 9/7 design performed efficiently in the area utilizations as well as in the power utilizations. The principle highlights of the architecture are less difficulty, efficient speed, minimum hardware utilization and low power consumption. In the field of the image and video compression, the efficient VLSI design is proposed. Discrete wavelet transform is one of the most utilized methodologies for image compression. The image coding and the compression efficiency with the DWT are higher than discrete cosine transform. In image compression, Image de-noising, and signal de-noising DCT is utilized in the field of the image compression, where as wavelet transform is too dynamic. Wavelets can deliver enhanced image with DCT. Wavelets have the ability to represent signal/image in time-freq constraint which Fourier basis is just well represented in the frequency domain.

4.2 Discrete Wavelet Transform (DWT) For Image Compression

Discrete Wavelet Transform (DWT) is a system utilized as a part of the image processing field for compressing the image. Compression is fundamental to generate the simplicity of data transmission and data storage. The discrete wavelet change has been widely utilized by various research analysis recently because of its amazing structure and time-frequency attributes. The discrete wavelet transform (DWT) transforms the digital signals. That signal transformation is performed from the time domain into frequency domain. Due to the various advanced features, the discrete wavelet
transform (DWT) is being utilized as a part of the various present applications like speech compression. That speech compression gives the fastest data transmission in the mobile communication systems. DWT is mostly used in the part of medical applications area and also DWT is widely applied in the denoising, feature extraction and so on.

Various research analyses are made by using the wavelet transform included in the JPEG standard as many years. Discrete cosine transform (DCT) generates the blocking artifacts at the high compression rates of the image. The given input image is divided into the sub blocks (8 x 8 or 16 x 16) and the DCT is performed efficiently at the each sub blocks of the given input image. In between the adjacent blocks and boundaries, the mismatch occurred due to the high compression rates of the image compression. The sub blocks of the given input image appeared as the reconstructed image due to the mismatch. However, the Discrete Wavelet Transform (DWT) can perform the overall given input image in the row by row order to eliminate the generation of the blocking artifacts. The discrete cosine transform (DCT) is performed by utilizing the high number of the hardware resources. But in the case of the DWT, the transformation is achieved efficiently with the minimum number of the hardware utilizations. Image decomposition is performed in the row by row position so the DWT operations are simple with the less number of resource utilizations as compared to the DCT. Because of these convincing elements, the Discrete Wavelet Change is coordinated in the most understood norms like JPEG2000, MPEG-4, and so on.

4.2.1 General View for Wavelets

Wavelets are sets of general functions utilized as a part of the signal analysis and image compressions. For some decades, researchers required to utilize functions for the signal representations. Wavelets are generally known as the functions that are prepared as a superposition of some set of the general
functions for the most utilized approximating information. Wavelets are appropriate for approximating information with sharp discontinuities. Wavelets are one of the most appropriate functions of the entire waveform and also it decays as early. In the wavelet analysis, the transformation generally use the prototype function called “Mother Wavelet”.

4.3 Three Level Discrete Wavelet Transform (DWT) With Image De-composition

Discrete Wavelet change (DWT) is a numerical model for the image decomposition which is mainly applied in the various fields like image processing, image compression and water marking. It mainly divided the given input image into the various sub blocks called as Wavelets. Wavelets are made by interpretations and enlargements of a fixed function called mother wavelet. Wavelet transform gives both time and frequency domain information of the image. Multi-resolution analysis performs the signal processing with the varied separate frequency ranges. Discrete Wavelet Transform (DWT) is appropriate to recognize the area of the image where it can be embedded effectively. This property permits the misuse of the masking impact of the human visual system with the end goal that if a DWT co-productive is altered, it alters just the district relating to that coefficient. The high recurrence part contains data about the edge of the image so this frequency sub-groups are typically utilized for watermarking since the human eye is less sensitive to changes in edges so this frequency sub-bands.

Discrete Wavelet Transform (DWT) divides the given input image into the two separate low and high frequency signals. In the low frequency part it includes the signal information and the high frequency part that contains the edge components information. When the human eye is sensitive to the capture the image in the edge information, the high frequency components are applicable in the watermarking applications. In the two dimensional discrete wavelet transform (2D-DWT), the image decomposition is performed at each
step. At first stage of the decompositions, DWT is performed at the vertical direction and then horizontal direction. After the first level of decompositions, there are four sub bands are available in the image. That is, LL1, LH1, HL1 and HH1. After each successive level of decomposition, the LL sub band of the previous stage is used as the input stage of the image. To perform the two level wavelet transform, the DWT is performed at the LL1 and also LL2 band is used to perform the DWT for the three level wavelet transform. At the final stage, the sub-bands of the image are carried out that are LL3, LH3, HH3 and HL3.

![Image Decomposition of the Three Level Discrete Wavelet Transform](Figure 4.1)

**Figure 4.1 Image Decomposition of the Three Level Discrete Wavelet Transform**

### 4.4 Proposed Lifting Scheme Based Discrete Wavelet Transform (DWT)

In the lifting based wavelet transform, the compressed image gets through the below steps.
1. The data information gets separated into even and odd samples. Second, the even signal samples are multiplied by the predict block.

2. Then the synthesis results are added to the odd samples of the given input image to create the point by point coefficients (dj). Detailed coefficients bring about high pass filtering.

3. By using the update factors the details coefficients of the predict step are multiplied and after that the outputs are added to the even examples to get the coarse coefficients (sj). The coarser coefficients generates the low pass filter output.

Various levels of the image compression can be performed by using the modified lifting based discrete wavelet transform. Lifting method discrete wavelet transform (DWT) is performed with the minimum arithmetic complexity when compared to convolutional DWT methodology. Due to the minimum complexity, the lifting based method is much faster than the convolutional method. Nowadays, the lifting based proposed methodology is mainly used in the image and signal processing. That is in the first level of image compression the LL, LH, HL, HH groups are delivered. At that point the second level of image compression the LL band again subdivided into four sub-bands. It is the more compressed than the first level of image compression stage.

The LLLL band in the second level of compression again subdivided into four sub-bands, which is the efficient compressed image than the second stage of image compression.

The low pass sub groups of the odd and even examples are controlled by the scaling step. The lifting techniques accomplish the part of the high pass and low pass filters into the sub samples of the upper and lower samples and furthermore the execution of the filter is transformed into the multiplication matrixes.
The upper and lower triangular matrix appear above for wavelet transform. The L is signifying the lower triangular grid and the U is meaning the upper triangular matrix. Lifting technique is utilized to decrease the computational complexity of the execution of the wavelet transformations and furthermore it used to eliminate the memory components for storing the simulation results. The requirement of the memory utilized for storing the simulation output is limited by utilizing the lifting method than the traditional approach. In the wavelet implementations, the memory essential of the storage purpose are highly utilized in the conventional approach but in the case of the proposed lifting scheme, the memory utilization is efficient. There are two blocks are utilized to fabricate the 2D-DWT block that is, Predict and Update block. To process the high coefficients, the info pixels are associated with the predict block. In the same time duration, the output stage of the predict block is associated with the update block to create the lower coefficients for pixels.
The predict block requires some information pixels that is, IP_i, IP_{i+1}, IP_{i+2}, IP_{i+3} and IP_{i+4}. Also, IP_i, IP_{i+1}, IP_{i+2} input pixels are required for the update block. For estimation of the Xi and Yi, some measurements of pixels are required. In the proposed strategy, there are five pixels required for deciding the Xi and three pixels are required for the Yi calculations. Split, Predict, Update and Scaling steps are essentially used to produce the lifting technique plans.

4.4.1 Methodology of the Lifting Scheme

The proposed lifting method is used for the image compression by utilizing multilevel two dimensional and furthermore the filters are mainly used to decrease the equipment usages and the system is more viable for FPGA structures.

![Figure 4.3 Lifting Method Structure](image)

**Figure 4.3 Lifting Method Structure**

\[
L = \begin{pmatrix}
L_{1,1} & \cdots & 0 \\
\vdots & \ddots & \vdots \\
L_{n,1} & \cdots & L_{n,n}
\end{pmatrix}
\]  \hspace{1cm} (4.1)

\[
U = \begin{pmatrix}
U_{1,1} & \cdots & U_{1,n} \\
\vdots & \ddots & \vdots \\
0 & \cdots & U_{n,n}
\end{pmatrix}
\]  \hspace{1cm} (4.2)
There are two primary blocks of the structure utilized to play out the lifting technique that is, Predict block and update block. To register the larger amount of coefficients, the given input samples are given to the predict block and the output stage of the predict block is given to the input stage of the update block. The update block is utilized to compute the lower level of coefficients of the given input samples.

4.4.1.1 Performance Of the Predict Block

In the Predict block, the each clock pulse of the input samples is overlapped and the details of the given input samples are overlapped at the input five pixels. There are four pre determined values are registered in the registers, A, B, C and D.

![Figure 4.4 Flow Diagram of the Predict Block Performance](image)

Four multipliers and two adders are utilized as a part of the predict block. The multiplier is for creating the output stage to the delay register and the output stage of the delay register and is associated with the adder stage. The adder stage is initialized by the zero in the given input samples and the
values of the samples are stored in the delay register. At that point the output stage of the adder block is again forwarded to the predict block. These operations are performed at the each phase of the info tests.

**4.4.1.2 Performance of the Update Block**

By utilizing the strip based strategy, the given input pixels are read and the last pixel is covered by the each single clock pulses. In this block of operations, there are three steady values are pre processed to be specific, $\alpha$, $\beta$, $\gamma$ and these qualities are put away in the storage register. Four multipliers and one adder is required to perform the update operations. Addition block operations are executed as same in the predict block operations. The lower levels of coefficients are determined by the update block. At the last stage, both the higher and lower co-proficient is scaled by utilizing the scaling factor.

![Figure 4.5 Flow Diagram of the Update Block Performance](image-url)
In 2D-DWT, the data chosen from the given input image is performed by the multiplexer. The information is partitioned into the four sub groups. That is, LL, LH, HL and HH. The LL band sends the data to the transformation block to play out the following level image decompositions levels. At that point, the LL band of the information is additionally decomposed into the LLLL, LLLH, LLHL and LLHH. At the last stage, the LLLL band performed the final stage of the image decompositions. 1-Dimensional wavelet transform operate the image into the row and column can be decreased by the 2-Dimensional wavelet transform. The sub band of the given information is created by applying the straight forward approach for both row and column of the image. Two designs are utilized as a part of the 2D-wavelet implementation stage. They are, level by level and line based design. In case of System on Chip (SoC), the power consumption is high as well as the hardware utilization is high by using the external memory access. The line based architecture performs with the input buffer and data buffer. The data buffer is proportional to the number of the register nodes. The lifting scheme for DWT transformation reconstitutes the low and high filter of the traditional method by samples of the modified filter.

4.5 Simulation Results for Lifting Scheme

Lifting scheme is based on Two Dimensional Discrete Wavelet Transform (2D-DWT) is designed and implemented by using MATLAB and ModelSim XE. By using the MATLAB, the mathematical functions of the DWT functions are designed. The image compression is efficiently performed in MATLAB. ModelSim XE software is used to implement the VLSI based lifting architecture. Simulations of the lifting scheme are carried out by using the ModelSim XE. To determine the efficiency of the proposed lifting scheme, the constraints are carried out by using the Xilinx ISE. The main concerns of VLSI system design environment are to reduce the hardware utilization, delay consumption, and power consumption. The synthesis result has been validated
by using Xilinx 10.1i (Package: pq208, Family: Spartan-3, Device: Xc3s200) design tool.

Figure 4.6 Simulation Output for the Three Level Discrete Wavelet Transform (DWT)

Figure 4.7 Simulation output for the Lifting Scheme (Predict method)
Figure 4.8 Simulation Output for the Lifting Scheme (Update method)

Figure 4.9 Synthesis Result of the Look-up-Table (LUT)

Utilizations of the Proposed Lifting Method
Figure 4.10 Synthesis Results of the Delay Utilizations of the Proposed Lifting Method

Table 4.1 Comparison Tabulation Analysis for the Conventional and Proposed Discrete Wavelet Transform (DWT)

<table>
<thead>
<tr>
<th>Design Description</th>
<th>Look-up-table (LUT)</th>
<th>Delay (ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Three Level DWT</td>
<td>93</td>
<td>5.496</td>
</tr>
<tr>
<td>Proposed Lifting based Three Level DWT</td>
<td>34</td>
<td>4.873</td>
</tr>
<tr>
<td>Percentage Reduction</td>
<td>63%</td>
<td>11.35%</td>
</tr>
</tbody>
</table>

From the above synthesis analysis, it is clearly shown that the Lifting scheme is better for the efficient Discrete Wavelet Transform (DWT) and the
Multi-band wavelet transform is efficient in terms of the filters requirement for the minimum hardware utilizations. The performance of proposed method has been improved in terms of less silicon area utilization, high speed and lower power consumption than the existing method.

Figure 4.11 Graphical Representation of the synthesis analysis for Conventional Three level DWT and Proposed Lifting based Three level DWT

4.6 Summary

In this research work, Two Dimensional Discrete Wavelet Transform (2D-DWT) is designed with the efficient image compression technique such as, Lifting Scheme. VHDL Language is used to implement the lifting method based on Discrete Wavelet Transform (DWT). The memory elements requirements are highly reduced than the conventional methodology and also the data loss is highly reduced in the lifting based image compression scheme. Data buffer with the 4N size filter is the only requirement for the design of the 2D-DWT implementation. To perform the image compression, the MATLAB
R2013A tool is used and ModelSim XE is used for the VLSI based architecture design. Xilinx ISE is used for the synthesis the proposed in terms of the VLSI Design Environment. When compared to the conventional three levels discrete wavelets transform, the lifting method offers 63% reductions in the Look-Up-Table (LUT) utilizations and 11.35% reductions in the computational delay. From the above synthesis analysis, it is clear that the Discrete Wavelet Transform (DWT) based Lifting scheme have several advantages. Finally the Lifting scheme is incorporated into the Discrete Wavelet Transform (DWT).