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GABOR WAVELET TRANSFORMATION WITH PHASE SHIFT INVARIANCE FOR QUALITY LOSSLESS IMAGE COMPRESSION AND DECOMPRESSION

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ABSTRACT- **An image compression is essential for transmission and storage of digital images. Many research works are developed for lossless image compression and decompression. However, higher quality lossless image compression was not achieved. The Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method is proposed to enhance the quality of image being compressed and decompressed with higher compression ratio. Initially, GWT-ICD Method used Gabor Wavelet Transformation with phase shift invariance that decomposes the image into a set of wavelet coefficient with change in angular position to adjust the size of image for efficient image compression. After the decomposition, GWT-ICD Method quantizes the wavelet coefficients with the aid of vector quantization process. Next, Run length encoding is performed in GWT-ICD Method to remove redundancy in the form of repeated bit patterns in output of quantization which in turn reduced the overall size of image for transmission with lower compression time. Finally, image decompression process is performed for image reconstruction. Therefore, GWT-ICD Method restores the original image by performing decoding, de-quantization and then an Inverse Gabor Wavelet Transformation with phase shift invariant. The GWT-ICD Method conducts the simulations works on the metrics such as compression ratio, compression time, and space complexity. The simulation results illustrate that the GWT-ICD Method is able to attain higher compression with reduced space complexity for performing lossless image compression when compared to state-of-the-art-works.**

Keywords: **Gabor Wavelet Transformation, Image Compression, phase shift invariance, wavelet coefficients, Run length encoding, compression ratio**

1. INTRODUCTION

Image compression is significant for transmission and storage in data bases. Image compression process is employed to compress the image which reduces the storage and transmission time. There are two categories of image compression called lossy and lossless. The lossy Image compression lessens the bits needed for storing or transmitting an image without considering the image resolution. The lossless image compression focuses on preserving the quality of the compressed image so that it is same as the original image. Recently few research works has been designed for lossless image compression and decompression. But, there is need for new technique to achieve lossless image compression with enhanced image quality.

A DCT-based non-predictive image coding system was presented in [1] for efficient image compression. The DCT-based non-predictive image coding system improves the compression ratio of image compression. But, the performance of image compression was not sufficient for attaining higher image quality. An integer DTT (iDTT) scheme was intended in [2] to achieve integer to integer mapping for efficient lossless image compression. However, image compression time was not considered.

A 2D-stationary wavelet transform (SWT) was developed in [3] for performing lossless compression through minimizing the amount of data required to represent a digital MRI image. But, lossless compression performance was not efficient for achieving higher image quality. An improved medical image compression technique based on region of interest (ROI) was designed in [4] to get better compression performance and to obtain higher compression ratio. However, it takes more compression time.

A Novel Image Compression Algorithm was presented in [5] for high resolution 3D reconstruction and providing high quality compression with high compression ratios. Though, the space complexity for storing the compressed image was more. A novel color image compression scheme based on the contrast sensitivity characteristics of the human visual system (HVS) was introduced in [6] for attaining higher image compression ratio and enhancing visual perception of the decompressed image. But, compression time was higher. Wavelet Based Algorithm was designed in [7] to perform lossless satellite image compression and decompression for storage system.

A novel lossless colour image compression scheme was intended in [8] with the aid of a reversible color transform (RCT) and Burrows–Wheeler compression algorithm (BWCA) that reduces the compression and decompression times. However, the compression ratio was not sufficient. An efficient compression of color images with Wavelet Difference Reduction (WDR) coding and prediction error quantization was developed in [9] to obtain high compression performance without degrading the quality of reconstructed images. But, the compression time taken for higher quality image reconstruction is higher.

A novel lossless compression scheme was designed in [10] to compress Bayer CFA images represented in HDR (High Dynamic Range) format and to improve the compression efficiency. Though, compression efficiency was not at required level. Lossless Medical Image Compression was performed in [11] by Integer Wavelet and Predictive Coding to compress the medical data and to improve the performance of lossless compression. But, higher image quality was not attained during decompression.

Based on the above mentioned techniques and methods presented, Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method is introduced. The research objective of GWT-ICD Method is formulated as follows,

- To enhance the performance of image compression with higher compression ratio and improved image quality, Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method is designed.
- To decompose the image into number of wavelet coefficients, Gabor Wavelet Transformation with phase shift invariance is employed in GWT-ICD Method.
- To quantize the wavelet coefficients for image compression, Vector Quantization technique is used in GWT-ICD Method.
- To lessen the overall size of image and to reduce the compression time, entropy encoding is performed in GWT-ICD Method.

The rest of this paper is organized as follows. Section 2 explains Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method with the assist of architecture diagram. Section 3 and Section 4 explains the experimental settings and details performance analysis with the aid of parameters. Section 5 describes the related works. Finally, Section 6 concludes this paper.

2. GABOR WAVELET TRANSFORMATION BASED IMAGE COMPRESSION AND DECOMPRESSION METHOD

Image compression is important to reduce the file sizes which make it potential to reduce the processing time and transmission time and storage memory. In order to improve the performance of image compression and decompression with higher image quality, Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method is developed. The key objective of GWT-ICD Method is to achieve higher quality lossless image compression by using Gabor Wavelet Transformation with Phase Shifting Invariance. Gabor Wavelet Transformation provides the time and frequency representation concurrently. Gabor Wavelet Transformation based on image compression adopts the fast algorithm for two dimensions. This Gabor Wavelet Transformation decomposes original image into four sub parts after passing the image into high pass filter (H) and low pass filter (L). The four sub bands or wavelet coefficients are LL, HL, LH and HH respectively. LL is a low frequency wavelet coefficient of approximate image. HL is a high frequency wavelet coefficient of the horizontal details of the image. LH is a high frequency wavelet coefficient of the vertical details of the image. HH is a high frequency wavelet coefficient of diagonal details of the image. Besides, Phase Shifting Invariance is applied in GWT-ICD Method for changing the angular position of images to adjust the size of image for compression. The architecture of Gabor Wavelet Transformation based Image Compression and Decompression Method is shown in below Figure 1,

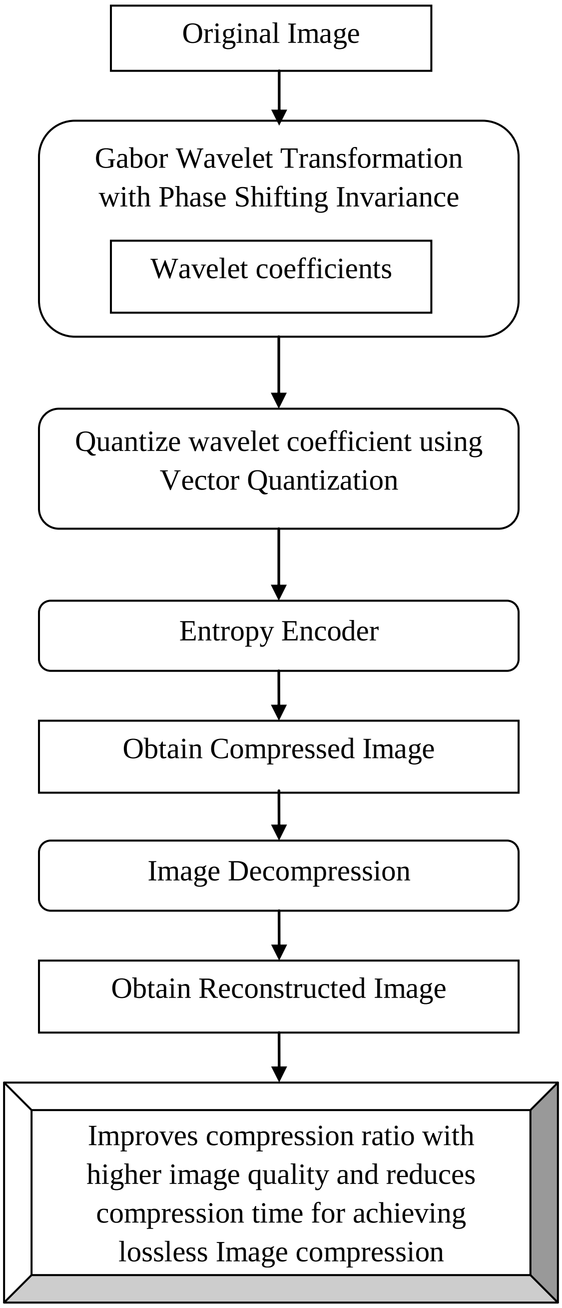

Figure 1 Gabor Wavelet Transformation based Image Compression and Decompression Method using Phase Shift Invariant

As shown in Figure 1, initially GWT-ICD Method takes the images as input and then applies Gabor Wavelet Transformation with phase shift invariant. The Gabor Wavelet Transformation with phase shift invariant used in GWT-ICD Method splits the image into wavelet coefficients or sub bands namely LL, LH, HL, and HH with change in angular position to adjust the size of image for efficient image compression. After that, MAWT-ICD Technique is performs Vector Quantization to quantize the wavelet coefficients to be transmitted for image compression. Next, GWT-ICD Method employed encoder to lessen the overall size of image which resulting in compressed image. This compressed image is transmitted through internet for reducing the space complexity during the transmission. Finally, the image decompression process is accomplished in order to acquire the reconstructed image. The decompression is reverse process of image compression to obtain the reconstructed image. This in turn assists for GWT-ICD Method to enhance the compression ratio with minimum execution time. The detailed explanations about GWT-ICD Method are described in following subsections.

2.1 GABOR WAVELET TRANSFORMATION

The Gabor wavelet transformation of an image representation is given through the convolution with a Gabor filter set. Gabor filters are selective in frequency and orientation. Gabor filters splits an image into multiple orientations and scales. The gabor filters are a set of wavelets where every wavelet containing energy at a definite frequency and specific orientation. Let consider an input image I is represented by M pixels and F is Fourier transform. Besides, W_o denotes the linear Gabor wavelets transform. g_iAnd G_i indicate the Gabor filters in the frequency and spatial domain respectively. The transformation of image I by W_o is called decomposition of image which gives the wavelet coefficients $(C_{i,X})_{i,X}$ in which $i=(k,o)$ indexes the frequency coordinates (i.e. channel) and X indexes the spatial coordinates. Let N denotes the number of real coefficients in the transform space. Due to the non-orthogonality property $N>M$, gabor wavelet transformation get an over complete or redundant representation. Let $\{C_i\}$ represents the different channels given by down sampling the convolution between the image I and the filters which is mathematically expressed as,

$$C_i =\downarrow_i (G_i \otimes I) \qquad (1)$$

From the equation (1), $\otimes$ indicates the convolution operator. Thus, the Gabor wavelet transformation for image compression is mathematically represented as below,

$$W(I)=(C_i)_i=(F^{-1}(\downarrow_i (g_i I)))_i \qquad (2)$$

In addition, the inverse gabor wavelet transformation W^{-1} for decompression to obtain reconstructed image is mathematically formulated as below,

$$W^{-1}(I)=\sum_i(\uparrow C_i)\otimes G_i \qquad (3)$$

$$W^{-1}(I)=F^{-1}(\sum_i(\uparrow C_i)g_i) \qquad (4)$$

The reconstruction of image is exact if: $\forall I, W^{-1}(W_o(I))=I$ and therefore applying the equation (2) in (4) provides,

$$\sum_i(g_i)^2=1 \qquad (5)$$

From the equation (5), $\sum_i(g_i)^2=1$ called as rosette the square sum of the filter set. In order to perfectly reconstruction the compressed image, such square should sum up to one. The process of Gabor Wavelet Transformation for Image decomposition is shown in below Figure 2.

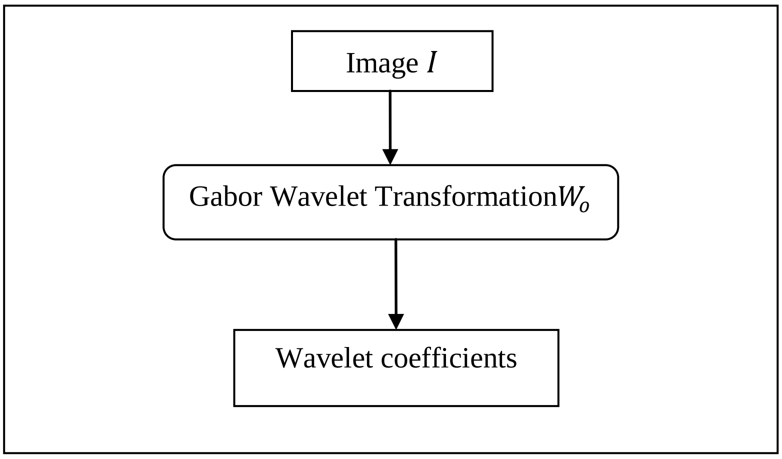

Figure 2 Gabor Wavelet Transformation for decomposition

As shown in Figure 2, initially the image is taken as input and then applies Gabor Wavelet Transformation that decomposes the images into four wavelet coefficient namely LL, LH, HL and HH. This process is called the first level of wavelet decomposition. The low frequency wavelet coefficient is repetitively decomposed into four wavelet coefficient. Theoretically the decomposition process is infinitely performed in order to improve the quality of the reconstructed image. Researchers generally employ the third level of decomposition for improving the performance of image compression and to achieve higher quality image. The three level Gabor Wavelet Transformation based decomposition model is shown in Figure 3.

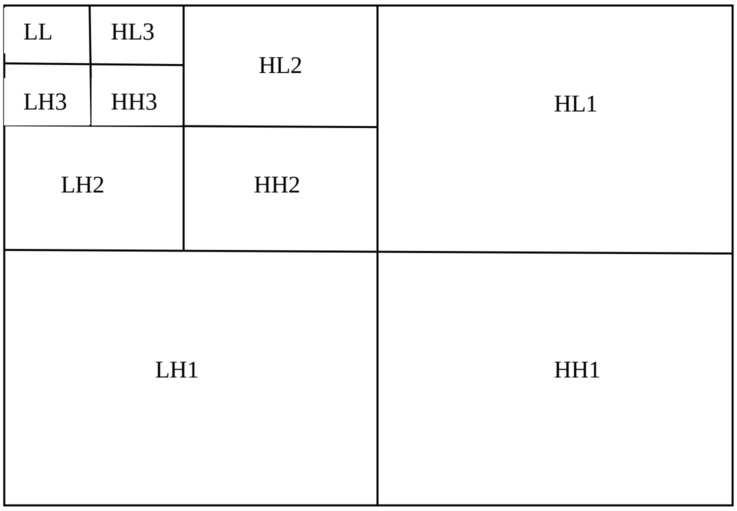

FIGURE 3 REPRESENTATION OF THREE LEVEL GABOR WAVELET TRANSFORMATION FOR IMAGE DECOMPOSITION

As shown in the Figure 3, the Gabor Wavelet Transformation gives the four wavelets coefficients such as LL, LH, HL and HH during the image decomposition process. After obtaining the wavelets coefficients, GWT-ICD Method applies Phase Shifting Invariance that changes the angular position of images to adjust the size of image for compression which in turn reduces the space complexity for image transmission. The Phase Shifting Invariance function for wavelet coefficients of image is mathematically formulated as,

$$PSI = AsinB(x + \phi) + C \tag{6}$$

From the equation (6), A denotes the size of wavelet coefficients of image, B is time period. Here, ϕ represents the phase shifting of image (left/right) where as C indicates the shifting of image (up/down). The C is divided by ϕ to find phase shifting angle. The phase shifting angle represents the horizontal movement of image as demonstrated by their size and time periods. If ϕ / B is positive, the image is phase shifting towards the right and if it is negative, the image is phase shifting towards left. The angular position of image is changed while applying the Phase Shifting Invariance according to the phase shifting angle and then the image gets orientated in a given memory space therefore GWT-ICD Method reduce the space complexity during the image transmission process.

2.2 QUANTIZATION

In GWT-ICD Method, Quantization is performed to lessen the number of bits required to store the transformed coefficients. Quantization is carried out on each individual coefficient which is termed as Scalar Quantization (SQ). The Quantization accomplished on a set of coefficients together is called as Vector Quantization (VQ). The Vector Quantization (VQ) is an efficient and simple approach for lossless image compression. Hence GWT-ICD Method used VQ for quantization process of image compression. The VQ process comprises of four steps namely vector construction, Training set selection, codebook generation and quantization. The initial step is to separate the input image into set of vectors. The Subset of vectors in set is afterward selected as a training sequence. The codebook of codewords is acquired with the help of an iterative clustering algorithm. At last, for quantizing an input vector, closest codeword's in the codebook is identified and equivalent label of this code word is transmitted. During this process, data compression is attained.

The objective of the VQ is to increase the compression rate with high fidelity. The design of VQ is based on the selection of codebook. For compressing image, the operations of VQ include splitting an image into number of vectors and all vectors are matched to code words of a codebook to identify its regeneration vector. In other words, the goal of VQ is the representation of vectors $X \subseteq R^k$ by a set of reference vectors $CB = \{C1, C2, \ldots, CN\}$ in which $R^k$is the k dimension Euclidean space. The CB is a codebook which has a set of reproduction code words and $C_j = \{c_1, c_2, \ldots, c_k\}$ is the jth code word. For codebooks generation, VQ requires Linde–Buzo–Gray (LBG) algorithm. The performance of LBG algorithm depends on initial codebook. The following block diagram shows VQ process for image compression is shown in below Figure 4,

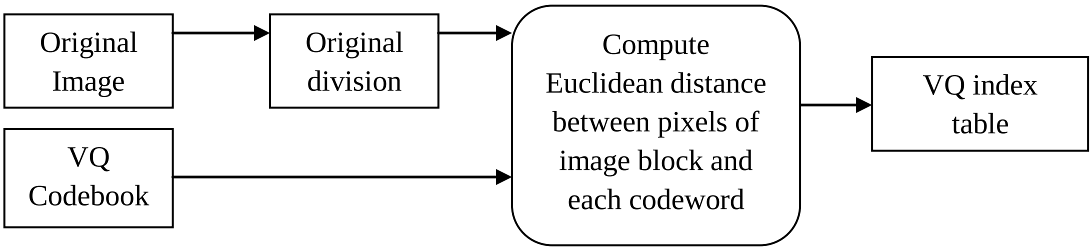

Figure 4 VQ Process for Image Compression

Figure 3 shows a diagram of compressing one image block with the size of 4×4 pixels. The size of the codebook is 128 in which each codeword comprises of 16 pixels. The first divided image block consists of 16 pixels. Then, the Euclidean distance among the pixels in image block and every codeword in codebook is evaluated. The codeword with the minimum Euclidean distance implied that the codeword is similar to the image block. Therefore, the image block is replaced by the index of most similar codeword. The following block diagram shows VQ process for image decompression is shown in below Figure 5.

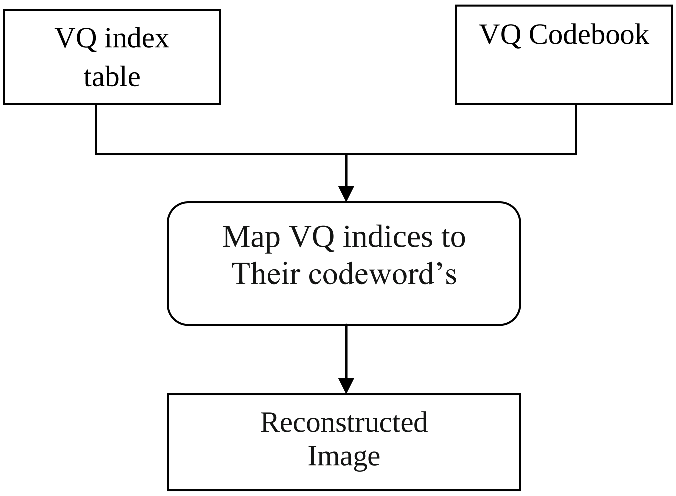

Figure 5 VQ Process for Image Decompression

As shown in Figure 5, during the image decompression process, the VQ index is mapping to the codeword in the codebook to reconstruct the image block.

2.3 ENTROPY ENCODING

In GWT-ICD Method, an entropy encoder compresses the quantized wavelet coefficient values losslessly to afford a better overall compression for transmission or storage. An entropy encoder efficiently identify the probabilities for each quantized value and generates a suitable code depends on these probabilities. Therefore the output code stream is smaller than the input stream. The frequently utilized entropy encoders are the Huffman encoder and the arithmetic encoder and Run Length Encoding. Run Length Encoding is very effectual for lossless image compression with fast execution. In addition, Run Length Encoding is significant to achieve the best compression ratio with minimum time. Therefore, GWT-ICD Method is used Run Length Encoding in which pixel of input image have similar or nearest value with its adjacent pixel afterward both pixel values assumed as a identical intensity value in image. This in turn helps for improving the performance of image compression and therefore improves the compression ratio with reduced compression time.

2.4 GABOR WAVELET TRANSFORMATION BASED IMAGE COMPRESSION

Gabor Wavelet Transformation based Image Compression reduces the size of image for storage during transmission. The objective of Gabor Wavelet Transformation based Image Compression is to diminish the number of bits which are not required to represent data of image and to reduce the transmission time. The algorithmic process of Gabor Wavelet Transformation based Image Compression is shown in below,

```
// Gabor Wavelet Transformation based Image Compression Algorithm
Input: Aerial image dataset
Output: Compressed Image
Step 1:Begin
Step 2:  For each Image
Step 3:      Gabor Wavelet Transformation with phase shift invariance is applied to divide the
             image into four wavelet coefficients LL, LH, HL, and HH with change in angular
             position using (2) and (6) to adjust the size of image for compression
Step 4:      Apply vector quantization on set of wavelet coefficients for quantizing the wavelet
             Coefficients.
Step 5:      Entropy encoding is applied to lessen the overall image size for transmission
Step 6:  End For
Step 7:End
```

Algorithm 1 Gabor Wavelet Transformation based Image Compression

By using the above algorithmic process, GWT-ICD Method efficiently compresses the size of image with enhanced image quality which resulting in improved compression ratio with minimum time. With the help of Gabor Wavelet Transformation based Image Compression algorithmic process, GWT-ICD Method also achieves the lossless image compression for compressing the aerial image.

2.5 GABOR WAVELET TRANSFORMATION BASED IMAGE DECOMPRESSION

Finally, image decompression is carried out with the objective of obtaining the reconstructed image. The compressed file is initially decompressed and used. The decompression is the reverse process of image compression. The Gabor Wavelet Transformation based Image Decompression process is shown in below Figure 6.

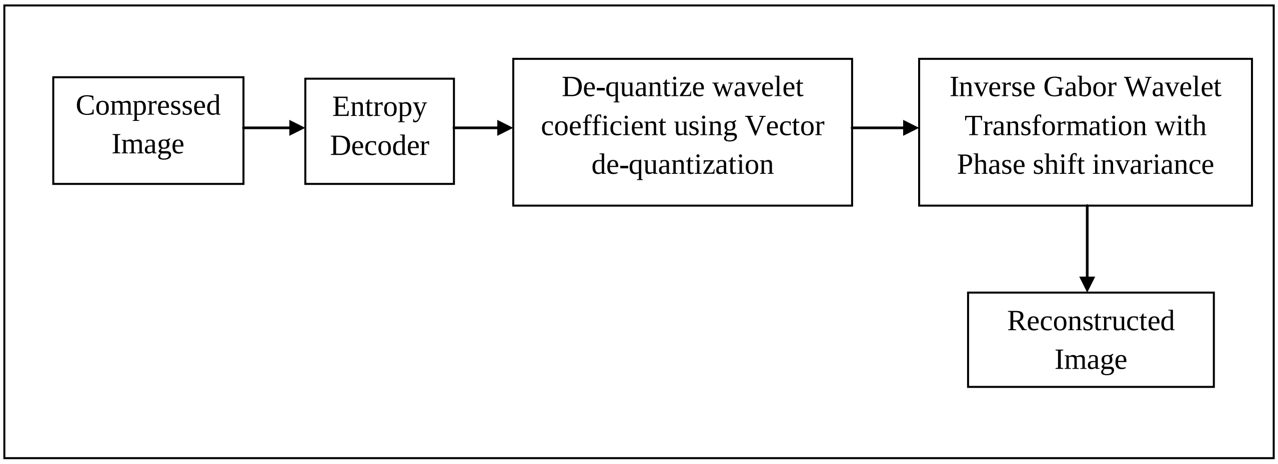

Figure 6 Gabor Wavelet Transformation based Image Decompression process

As shown in Figure 6, GWT-ICD Method restores the original image through accomplishing decoding, de-quantization and then an Inverse Gabor Wavelet Transformation with phase shifting invariant. The algorithmic process of Gabor Wavelet Transformation based Image Decompression is shown in below,

```
// Gabor Wavelet Transformation based Image Decompression Algorithm
Input: Compressed Image
Output: Reconstructed Image
Step 1: Begin
Step 2:   For each compressed image
Step 3:       Entropy decoding is carried out to convert an encoded format back into the original sequence of bits and therefore generates the quantized wavelet coefficient
Step 4:       Accomplish de-quantization process on decoded image
Step 5:       Apply Inverse of Gabor Wavelet Transformation with phase shift invariance to restore the reconstructed image using (4) and (6).
Step 6:   End For
Step 7: End
```

Algorithm 2 Gabor Wavelet Transformation based Image Decompression

By using the above algorithmic process, GWT-ICD Method efficiently restores the compressed image with higher image quality for achieving lossless decompression.

3. SIMULATION SETTINGS

In order to test the performance, Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method is implemented in MATLAB Simulator using aerial image dataset. This aerial image dataset comprises of 80 numbers of high-resolution aerial images with spatial resolution in the range of 0.3 to 1.0. The aerial image dataset set includes various scenes, including school, residential, city, warehouse and power plants. The size of each aerial image is 512-by-512 pixels. The GWT-ICD Method takes 10 aerial images form aerial image dataset for performing the simulation works. The effectiveness of GWT-ICD Method is compared against with the existing two methods namely DCT-based non-predictive image coding system [1] and integer DTT (iDTT) scheme [2].

4. RESULTS AND DISCUSSIONS

To validate the efficiency of the proposed, Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method is compared with existing DCT-based non-predictive image coding system [1] and integer DTT (iDTT) scheme [2]. The efficiency of GWT-ICD Method is evaluated along with the metrics such as compression ratio, compression time, and space complexity.

4.1 MEASURE OF COMPRESSION RATIO

The compression ratio computes the ratio of compressed image size using proposed GWT-ICD Method to that of the original input image size. The compression ratio is evaluated in terms of percentages (%) and mathematically represented as,

$$Compression\ \mathrm{ratio}\ = \frac{orginal\ \ image\ \ size - compressed\ \ image\ \ size}{orginal\ \ image\ \ size} * 100 \quad (7)$$

From the equation (7), compression ratio of different image is acquired. While the compression ratio is higher, the method is said to be more efficient.

Table 1 Tabulation for Compression Ratio

Image Name	**Size (KB)**	**Compression Ratio (%)**		
		DCT-Based Non-Predictive Image Coding System	**iDTT scheme**	**GWT-ICD Method**
Image-01	39.7	24.69	33.25	42.57
Image-02	42.7	24.82	32.32	43.09
Image-03	41.4	28.99	40.10	43.24
Image-04	60.2	29.40	37.04	45.68
Image-05	75.0	36.93	43.2	46.8
Image-06	45.5	23.96	38.24	43.3
Image-07	56.0	28.39	35.89	45.89
Image-08	57.8	32.18	42.39	48.79
Image-09	54.0	26.48	38.52	46.67
Image-10	53.2	32.71	40.04	48.31

Table 1 illustrates the compression ratio result is obtained based on different aerial images size. The GWT-ICD Method considers diverse numbers of aerial images as input for accomplishing image compression process. From the table value, it clear that the compression ratio using proposed GWT-ICD Method is higher when compared to existing DCT-based non-predictive image coding system [1] and iDTT scheme [2].

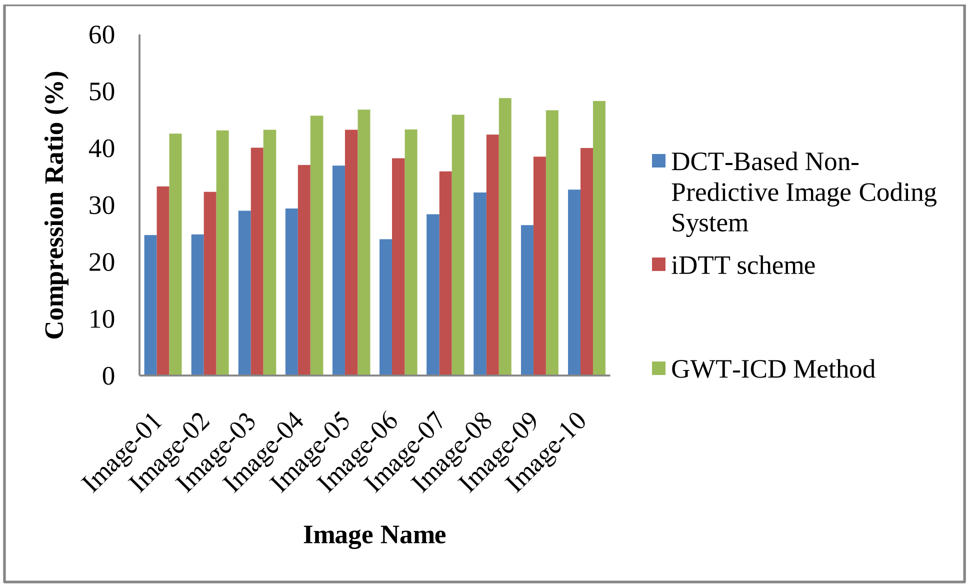

Figure 5 Measurement of Compression Ratio

Figure 5 presents the comparative result analysis of compression ratio with respect to diverse aerial images size using three methods. As shown in figure, proposed GWT-ICD Method provides better compression ratio as compared to existing two methods namely existing DCT-based non-predictive image coding system [1] and iDTT scheme [2]. This is owing to application of Gabor Wavelet Transformation with phase shift invariance in GWT-ICD Method that divides the image into a wavelet coefficient with change in angular position to adjust the size of image for effective image compression with higher image quality. After that, GWT-ICD Method applies VQ for quantizing the wavelet coefficients. At last, entropy encoding is carried out with the aid of Run Length encoding to lessen the overall size of aerial image. This in turn supports for GWT-ICD Method to improve the compression ratio in a significant manner. Therefore, proposed GWT-ICD Method improves the compression ratio by 60% when compared to DCT-based non-predictive image coding system [1] and 20% when compared to iDTT scheme [2] respectively.

4.2 MEASURE OF COMPRESSION TIME

The compression time measures the amount of time taken for compressing image. The computational complexity is evaluated in milliseconds (ms) and mathematically formulated as below,

$$Compression\ time = time(lossless\ image\ compression\ ) \qquad (8)$$

From the equation (8), image compression time for different image is obtained. While the compression time is lower, the method is said to be more efficient.

Table 2Tabulation for Compression Time

Image Name	**Size (KB)**	**Compression Time(ms)**		
		DCT-Based Non-Predictive Image Coding System	**iDTT scheme**	**GWT-ICD Method**
Image-01	39.7	17.1	13.5	10.9
Image-02	42.7	19.4	16.3	12.5
Image-03	41.4	18.6	15.9	11.9
Image-04	60.2	26.1	21.2	17.1
Image-05	75.0	30.9	24.5	19.8
Image-06	45.5	20.3	16.1	13.7
Image-07	56.0	21.7	16.7	12.9
Image-08	57.8	22.5	16.9	13.3
Image-09	54.0	21.9	15.4	12.8
Image-10	53.2	21.4	16.0	12.5

Table 2 demonstrates the compression time is obtained with respect to diverse aerial images size using three methods. From the table value, it descriptive that the compression time using proposed GWT-ICD Method is lower for attaining lossless image compression as compared to existing DCT-based non-predictive image coding system [1] and iDTT scheme [2].

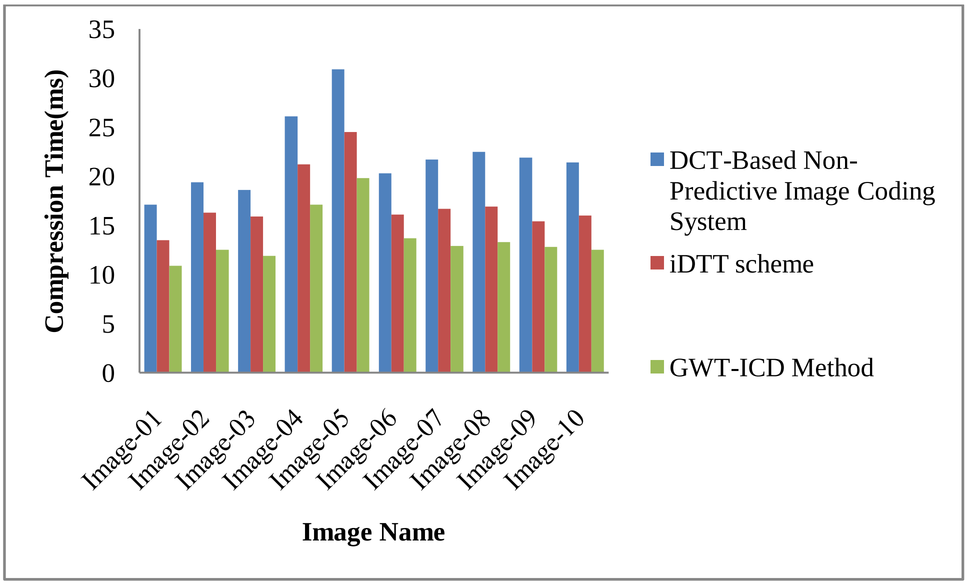

Figure 6 Measurement of Compression Time

Figure 6 shows the comparative result analysis of compression time versus different aerial images using three methods. As illustrated in figure, proposed GWT-ICD Method provides better compression time while compared to existing two methods namely DCT-based non-predictive image coding system [1] and iDTT scheme [2]. This is because of application of Gabor Wavelet Transformation based Image Compression Algorithm. With the support of this algorithmic process, proposed GWT-ICD Method efficiently compresses the aerial image with minimum time. Besides, GWT-ICD Method used phase shift invariance in decomposed wavelet coefficients that changes the angular position of wavelet coefficients to adjust the size of image for effectual image compression with higher image quality. This in turn helps for GWT-ICD Method to reduce compression time for achieving lossless image compression. As a result, proposed GWT-ICD Method reduces the compression time by 38% when compared to DCT-based non-predictive image coding system [1] and 20% when compared to iDTT scheme [2] respectively.

4.3 MEASURE OF SPACE COMPLEXITY

Space complexity measures the total amount of memory space taken for storing the compressed image. The space complexity is computed in terms of kilobytes (KB) and mathematically for expressed as,

$$Space\ Complexity = memory\ (storing\ compressed\ image) \qquad (9)$$

From the equation (9), the memory space needed for storing the compressed image is measured. While the space complexity is lower, the method is said to be more efficient.

Table 3 Tabulation for Space Complexity

Image Name	Size (KB)	Space Complexity (KB)		
		DCT-Based Non-Predictive Image Coding System	iDTT scheme	GWT-ICD Method
Image-01	39.7	29.9	26.5	22.8
Image-02	42.7	32.1	28.9	24.3

Image-03	41.4	29.4	24.8	23.5
Image-04	60.2	42.5	37.9	32.7
Image-05	75.0	47.3	42.6	39.9
Image-06	45.5	34.6	28.1	25.8
Image-07	56.0	40.1	35.9	30.3
Image-08	57.8	39.2	33.3	29.6
Image-09	54.0	39.7	33.2	28.8
Image-10	53.2	35.8	31.9	27.5

The space complexity results is obtained during the image compression process based on varied aerial images is depicted in Table 3. From the table value, it expressive that the space complexity using proposed GWT-ICD Method is lower as compared to existing DCT-based non-predictive image coding system [1] and iDTT scheme [2].

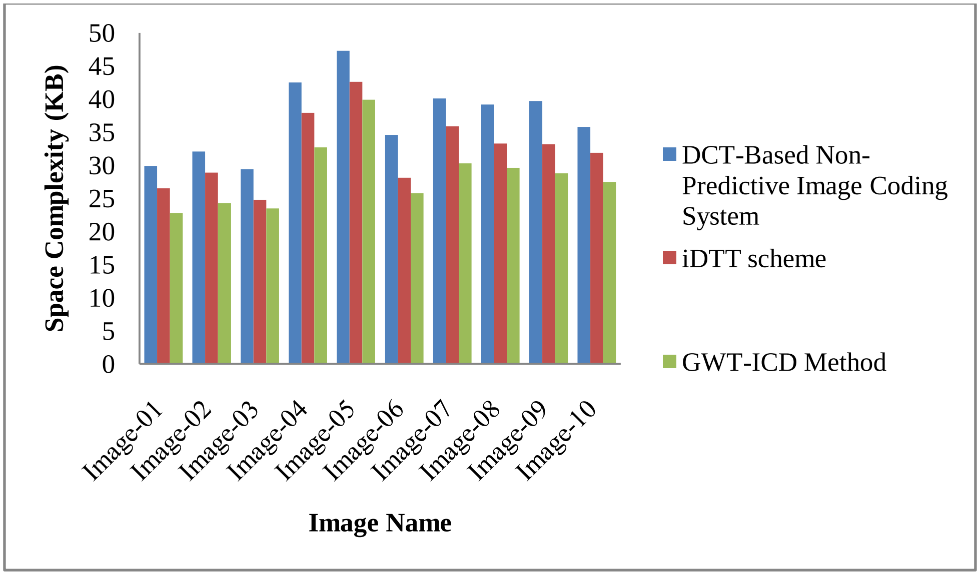

Figure 6 Measurement of Space Complexity

Figure 7 describes the comparative result analysis of space complexity for image compression versus different aerial images using three methods. As demonstrated in figure 6, proposed GWT-ICD Method provides better space complexity when compared to existing two methods namely Wavelet based volumetric medical image compression [1] and Wavelet based efficient image compression algorithm [2]. This is due to application of Gabor Wavelet Transformation based Image Compression Algorithm in GWT-ICD Method. With the assist of this algorithm process, proposed GWT-ICD Method initially separates the aerial image into four wavelet coefficients. Next, GWT-ICD Method phase shifting invariance for phase shifting angular position of image for efficient image compression. Then, quantization and encoding accomplished for further compressing the size of image. This in turn helps for GWT-ICD Method to reduce the space complexity for storing the compressed image. Hence, proposed GWT-ICD Method reduces the space complexity by 23% when compared to DCT-based non-predictive image coding system [1] and 12 % when compared to iDTT scheme [2] respectively.

5. RELATED WORKS

A lossless compression algorithm was designed in [12] through combining the integer wavelet transform with a prediction pre-processing step in order to improve compression performance in terms of compression ratio, computational cost. However, the computational time taken for image compression was not considered. Lempel-Ziv-Welch (LZW) lossless compression technique was introduced in [13] for attaining higher compression ratio.

An efficient lossless compression method was developed in [14] to enhance the compression efficiency with the aid of VQ indices based on principal component analysis (PCA) and the Huffman code. But, image compression ratio was poor. An integrated compression technique was intended in [15] that integrates quadrant tree decomposition (QTD) and lifting based discrete wavelet transform (DWT) to achieve high image compression performance at low bit rates without losing any information of image. Though, this technique takes longer time for compression process.

A low-complexity WCE image compression scheme was designed in [16] to achieve high compression efficiency through reducing the image size without a significant loss of image quality. Textual image compression scheme was presented in [17] to compress textual images by using the wavelet transform, Set Partitioning in Hierarchical Trees (SPIHT) coding, and reinforcing the wavelet coefficients in the framework of the region-of-interest (ROI) coding. Textual image compression scheme achieves higher compression ratio and improving the visual quality.

Haar Wavelet Based Approach was designed in [18] for performing image compression with improved quality assessment of compressed image. But, compression time was remained unaddressed. A Spatial Domain Image Compression Based on Hops Encoding was introduced in [19] for achieving lossless image compression with low computational complexity and higher image quality. Though, space complexity was more. A cuckoo search algorithm based vector quantization was presented in [20] for improving the peak signal to noise ratio and quality of the reconstructed image. But, computational complexity for compression was higher.

6. CONCLUSION

An effective Gabor Wavelet Transformation based Image Compression and Decompression (GWT-ICD) Method is designed to perform the aerial image compression and decompression. The GWT-ICD Method achieves a high compression ratio with acceptable visual quality through exploiting the advantages of Gabor wavelets transformation and phase shifting invariance. The GWT-ICD Method Initially divides the image into a set of wavelet coefficient with change in angular position with the application of Gabor Wavelet Transformation with phase shift invariance to adjust the size of image for effectual image compression. After that, GWT-ICD Method quantizes the wavelet coefficients via vector quantization. Subsequently, Run length encoding is carried out to eradicate redundancy in the form of repeated bit patterns in output of quantization. This in turn reduced the overall size of image for transmission with minimum compression time. At last, image decompression process is accomplished in order to reconstruct image. As a result, GWT-ICD Method restores the original image by means of performing decoding, de-quantization and then an Inverse Gabor Wavelet Transformation with phase shift invariant. The performance of GWT-ICD Method is test with the parameters such as compression ratio, compression time and space complexity. With the simulations performed for GWT-ICD Method, it is observed that the image compression ratio affords more precise results for lossless image compression when compared to state-of-the-art works. The simulations results reveal that GWT-ICD Method is offers better performance with an enhancement of compression ratio with compression time and reduced space complexity when compared to the state-of-the-art works.

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