



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH  
TECHNOLOGY**

**IMPROVED SVD-WDR BASED IMAGE COMPRESSION USING GRADIENT BASED  
OPTIMIZATION**

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**ABSTRACT**

Image compression has become very important tool in digital image processing. The main objective of the compression is to reduce the amount or unwanted data while retaining the information in the image. The goal behind is to save the amount of memory required to save the image(s) or to utilize network bandwidth in efficient manner. In this paper, a new method has been proposed in order to reduce blocking and ringing artifacts in compressed images. The proposed compression technique has integrated SVD-WDR compression with Gradient-based optimization approach for reduction of blocking artifacts in images. The edge restoration method has also been used as a post processing technique to remove the ringing artifacts from the compressed images.

**KEYWORDS:** IMAGE COMPRESSION, SVD-WDR, GRADIENT BASED OPTIMIZATION.

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**INTRODUCTION**

As use and reliance on computers continue to cultivate, so does our significance of efficient ways of storing wide range of data. For, example someone with a website or online catalog that uses dozens or perhaps hundreds of images will most likely need to utilize some form of image compression to store those images. This is because the total amount of space required to keep unadulterated images could be prohibitively large in terms of cost.[1]

Although we currently exist in a world of rapidly expanding computing and communication capabilities, with the escalation in computer awareness and, particularly, multimedia, the demand for computer systems and their applications to meet up people's needs can also be rising. Since every *bit* incurs a cost when being transmitted or stored, any technology which can be introduced into our existing systems that may reduce these costs is essential. When contemplating raw data that could contain over 50% redundancy, it raises the question – Why pay for that redundant information?

**TYPES OF COMPRESSION**

In the case of video, compression causes some information to be lost; some information at a depth level is considered not needed for an acceptable reproduction of the scene. This sort of compression is named lossy compression. Audio compression on one other hand, is not lossy. It is named lossless compression.[2]

**Lossless Compression**

Lossless techniques compress data without destroying or losing anything during the process. When the first document is decompressed, it's bit-for-bit identical to the original. Lossless is really a term applied to image data compression techniques where almost no of the first data is lost. It is typically utilized by the photographic and print media, where high definition imagery is needed and larger file sizes aren't a problem. In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the first image. However lossless compression can only just achieve a modest level of compression.[2]

**Lossy Compression**

Lossy is really a term applied to data compression techniques in which some level of the first data is lost during the compression process. Lossy image compression applications attempt to remove redundant or unnecessary information when it comes to what the eye can perceive. As the total amount of data is reduced in the compressed image, the file size is smaller than the original. Lossy schemes are capable of achieving higher compression. Under normal viewing conditions, no visible loss is perceived (visually lossless).

Lossy image data compression is ideal for application to World Wide Web images for quicker transmission across the Internet. An image reconstructed following lossy compression contains degradation in accordance with the original. Often this is because the compression scheme completely discards redundant information.[3]

**TYPICAL IMAGE CODER CONSIST OF FOLLOWING COMPONENTS**

A normal lossy image compression system which includes three closely connected components namely

- a) Source Encoder
- b) Quantizer, and
- c) Entropy Encoder.

Compression is accomplished by applying a linear transform to decorrelate the image data, quantizing the resulting transform coefficients, and entropy coding the quantized values.

**Source Encoder (or Linear Transformer)**

Over the years, a number of linear transforms have already been developed which include Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and a lot more, each having its own advantages and disadvantages.[4]

**Quantizer**

A quantizer simply reduces the number of bits needed seriously to store the transformed coefficients by reducing the precision of these values. Since this can be a many-to-one mapping, it is a lossy process and is the key supply of compression within an encoder. Quantization could be performed on every person coefficient, which is recognized as Scalar Quantization (SQ). Quantization can be performed on a small grouping of coefficients together, and this is recognized as Vector Quantization (VQ). Both uniform and non uniform quantizers can be used with respect to the problem at hand.[4]

**Entropy Encoder**

An entropy encoder further compresses the quantized values lossless to give better overall compression. It runs on the model to accurately determine the probabilities for every quantized value and produces an appropriate code centered on these probabilities so the resultant output code stream will be smaller compared to the input stream. The absolute most commonly used entropy encoders are the Huffman encoder and the arithmetic encoder, although for applications requiring fast execution, simple run-length encoding (RLE) has proven very effective. [5]

Information is, simply put, unexpected information. There is significant data content between, "It's 10:00 and all's well," and "Fire!" The longer message is expected, so we don't really think much about it--hence, little information. The shorter message is unexpected, and thus has quite high information content. One should basically judge the info content of an email by the difference in how one would act if they heard the message and if they didn't.

Consider another example: if I dropped a letter from a phrase so you only got "hel?o", you may probably reckon that the letter "l" was missing. Hence, the letter "l" in this context has little information. However, if I gave you with word "?ook", you may equally guess "l", "b", "h", "c", and so on. In this instance, the letter "l" might have significant information content. The same symbol might have different information content with respect to the context.

**VARIOUS TYPES OF REDUNDANCY**

Redundancy is the difference involving the shortest way you can convey a piece of information (i.e., the data content itself) and the information used to represent it. In the previous example, the very first "l" is highly redundant while the second "l" isn't. You will find three basic kinds of redundancy in images:

1. Coding Redundancy

2. Interpixel Redundancy
3. Visual Redundancy

All image compression algorithms attack more than one of such redundancy.

### Coding Redundancy

Pixels have to be encoded in images. Like everything in a pc, we've to assign some arbitrary pair of bits for different possible values. Sometimes, some values are far more probable than others. Therefore, they're more expected and thus have less information content. Others are less probable (less expected) and thus have more information content. The main element to cut back coding redundancy is to assign bits based on the information content. The more information, the more bits; the less information, the fewer bits. [5]

When we try to get rid of coding redundancy in textual information, we could gauge the frequency with which each letter occurs. If it occurs more often, encode it with as few bits as possible. If it doesn't occur much at all, use more bits. Thus, we might encode "E" with a couple of bits and "X" or "Q" with a lot of them. Who cares if "X" takes 12, 20, as well as 50 bits--it doesn't occur that often anyway.

Likewise, we could use such variable-length coding for pixels or other information for images. For instance, if a picture is 50 and 50 black pixels? You will want to play one bit to signal if the pixel is black or not, and then follow the non-black ones by the specific grey-level value (8 bits). This may play one bit for half the image and nine bits for one other half. This may use 4.5 bits per pixel in place of eight.

The very best known and most efficient method for variable-length encoding is Huffman coding. Pure Huffman coding is computationally expensive and requires measuring the entire statistics of the data. Typically, an altered form can be used that is dependent on presumed frequency distributions and not-quite-perfect encoding. [7]

### Interpixel Redundancy

*If you were to scan across a row of a binary image and read off the values, and if the values were |" white |", |" white |", |" white |", |" white |", |" white |", what would you guess the next one to be? While either |" black |" or |" white |" are possible, you'd probably guess that the next one is white. This makes sense for images because they usually have regions of constant or similar values. This is called interpixel redundancy.*

To be able to reduce steadily the interpixel redundancies in a picture, the 2-D pixel array normally employed for human viewing and interpretation must be transformed in to a more effective format. For instance, the differences between adjacent pixels may be used to represent an image. Transformations of this sort are called mapping. They are called reversible if the initial image elements may be reconstructed from the transformed data set.

A common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task then is to get less correlated representation of the image. Two fundamental aspects of compression are redundancy and irrelevancy reduction. Redundancy reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits elements of the signal that'll not be noticed by the signal receiver, namely the Human Visual System (HVS). Generally, three forms of redundancy could be identified:

- **Spatial Redundancy** or correlation between neighboring pixel values.
- **Spectral Redundancy** or correlation between different color planes or spectral bands.
- **Temporal Redundancy** or correlation between adjacent frames in a routine of images (in video applications).

Image compression research aims at reducing the number of bits needed seriously to represent an image by removing the spatial and spectral redundancies as much as possible. Since we will focus only on still image compression, we won't worry about temporal redundancy.[9]

### Visual Redundancy

The next way of reducing redundancy is to realize our senses aren't equally sensitive to any or all things. In this sense, information content pertains to the ability of our visual systems to share with the difference. Examples of this include

- Our greater sensitivity to changes in intensity than to changes in hue.
- Our greater sensitivity to low-frequency changes than to high-frequency ones.

By transforming our image into spaces that match these properties, we will then better reduce the number of bits we devote to them.

For instance, by transforming to YIQ color spaces, we separate intensity from color and can correctly apportion the bits. Likewise, by transforming to frequency-based spaces (such the frequency domains of the Fourier Transform or DCT), we could distribute our precious bits in accordance with spatial frequency. [7]

Psychological redundancy is fundamentally different from the redundancies discussed earlier. Unlike coding and interpixel redundancy, psychologically redundancy is related to real or quantifiable visual information. Its elimination is achievable only because the data itself isn't essential for normal visual processing. Since the elimination of psycho visually redundant data results in a loss in quantitative information, it is commonly known as quantization. This terminology is in keeping with normal usage of the term, which generally means the mapping of a wide range of input values to a limited number of output values. As it is an irreversible operation (visual information is lost), quantization results in lossy data. A wavelet is a "small wave", which includes its energy concentrated in time. It provides a tool for the analysis of transient, non stationary or time-varying phenomena. It not merely possesses an oscillating wavelike characteristic but also offers the capacity to allow simultaneous time and frequency analysis with a flexible mathematical foundation.

Traditional signal processing techniques such as for example fourier transform and short time fourier transform are poorly suited for analyzing signals which have abrupt transitions superimposed on lower frequency backgrounds such as for example speech, music and bio-electric signals. On another hand, the wavelet transform, a fresh tool, provides a novel way of the analysis of such signals. The wavelet transform features a multi-resolution capability. The multi-resolution signal processing found in computer vision, sub-band coding developed for speech and image compression, and wavelet series expansions developed in applied mathematics are recognized as different views of signal theory. The wavelet theory provides a specific frame work for numerous techniques which had been developed independently for various signal processing applications.[9]

## LITERATURE SURVEY

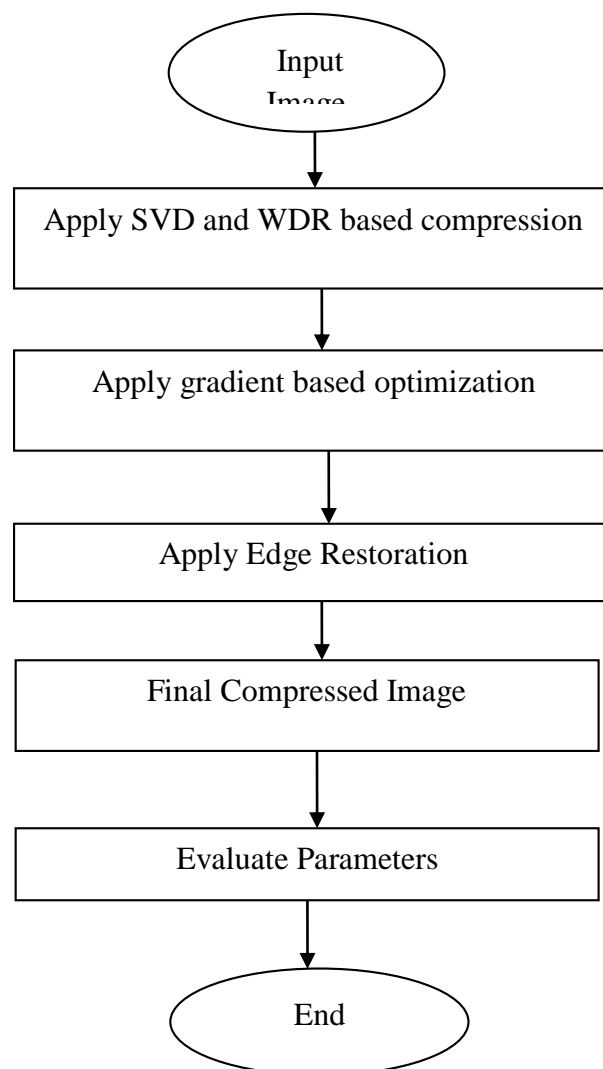
Patil, Neelamma K. et al. [1] proposed an efficient color and texture feature based adaptive color image compression. Color conversion from RGB to YCbCr was performed to extract color and texture features. The extracted features were used to pick non-zero (significant) DCT coefficients. The storage space and bandwidth during transmission was efficiently utilized by encoding non-zero DCT coefficients and thereby preserving texture and color information in the reconstructed image. Experimentation has been carried from different image formats successfully. The proposed technique is easy and straight forward. A great compression has been achieved with good MSE and PSNR. Experimental results for adaptive, using all coefficients and RGB color model with 20 coefficients were computed in terms of compression ratio and quality of reconstructed image are compared. The proposed adaptive method had achieved good compression ratio by retaining color and texture features. Mousa, Hamdy M. et al. [2] proposed image compression technique centered on conformal mapping transformation. The newest standard compression technique, JPEG2000 compression algorithm, is used. The proposed technique was tested with various images types. Two categories of image compression techniques (lossless and lossy) and with/without conformal mapping were studied. The experimental results showed that the compression ratio improves by 14% in average, and in case lossy image compression using JPEG2000 image quality gains over 2 dB in average. Thepade, Sudeep D. et al. [3] presented the extended performance comparison of HWT for image compression with varying the constituent transforms and the proportions of the constituent transforms to check the consequence on quality of image compression. The experimentation was done on group of 20 images by varying the constituent transforms, proportion of constituent transforms and compression ratios (CR). The constituent transforms used to generated HWT are Cosine transform, Sine transform, Slant transform, Kekre transform, Walsh transform and Haar transform. Here five proportions of constituent transforms alias 1:16, 1:4, 1:1, 4:1, 16:1 were considered for generation of HWT. Results proved that 4:1, 1:1, 1:4 proportions of constituent transforms in HWT gives better performance as compared to 1:1 proportion of constituent transforms for different compression ratios. Also for 95% compression ratio, 4:1 ratio of DCT-Haar constituent transforms in HWT gives better results. 1:1 ratio of DCT-Haar constituent transforms give better results for compression ratios between 70% and 90%. For lower compression ratios, 1:4 proportions of DCT-Haar constituent transforms in HWT gives better performance. Zhiqianga, Li et al. [4] made a degree analysis of JPEG image compression algorithm. Moreover, they focused on the JPEG encoding algorithm and made reveal description of JPEG encoder, decoder control processes. They also selected the original image to complete the Mat

lab simulation analysis centered on JPEG algorithm. Thirdly, using the DSP host processor, we can complete the hardware implementation of image acquisition and compression easily. Last however not least, this article selected a much better compressed image in order to complete image encryption process. Experimental results showed that JPEG image compression encryption algorithm was effectively guaranteed for the actual engineering applications and would be widely found in secure communication. Donapati, Srinivas et al. [5] analysed and compared the compression ratios of the images of different input formats particularly to RGB input format and YUV 444 format have been carried out to explore the results of CSC on the image compression when using the JPEG XR. An analysis of effective compression (better compression ratio) have been carried on various images of unique visual characteristics in numerous input formats when processed using JPEG XR. Leung, Tony et al. [6] investigated the effects of window level and window width adjustments on visibility thresholds. A JPEG2000 based image compression method to accomplish visually lossless compression for confirmed window level and width was then proposed. A validation study was performed to ensure that the images obtained using the proposed method can not be distinguished from original windowed images. The proposed compression method was also extended to a client-server setting where in actuality the server transmits incremental data to the client to ensure visually lossless representation after adjustments to the window level and width are manufactured at the client side. The proposed incremental compression method was compared to a reference compression system where an 8-bit image corresponding to the required window settings is created from a 12-bit CT image first at the encoder. This image was then compressed to accomplish visually lossless compression using the methods described in. Once the window settings are updated, a fresh 8-bit image corresponding to the updated window settings is created and compressed in a creatively lossless manner. A comparison of the two methods illustrate that while the reference system was more efficient when the display settings are changed only once, the proposed method was advantageous when the display settings are changed over and over again, requiring only 18% of the data transmitted by the reference system by the end of seven window setting adjustments. Gupta, Krishan et al. [7] presented a much better technique that will be faster, memory efficient and simple which surely suits the requirements of the user. This paper had three version of KG technique which named as KG1, KG2 and KG3. These techniques were invaluable in image compression but all have different solution to compress image. Compression ratio of image may also be different in these three version and better together which is dependent upon what kinds of image chosen for compression. For version 1: This technique named KG1 version. The technique used here, is much more helpful in reducing the bandwidth of an image and to increase of its availability, reliability, and transmission rates. For version 2: This technique named KG2 version. The techniques used listed here is extremely helpful in reducing data storage and transformation without any loss in an image. In this technique, an image compression domain algorithm aims at good performance in terms of image effectiveness. For version 3: This technique named KG3 version. They proposed the Lossless method of image compression and decompression. This technique was simple in implementation and utilized less memory. A pc software algorithm have been developed and implemented to compress and decompress the image. Xue, Y. et al. [8] did a compression to examine the effects of multi-spectral image compression with 5.8m resolution, which is used to instruct the onboard image compression design of these ZY-3 satellite series. The case study chose typical experiment area from a variety of land use categories including urban build-up, vegetation, water-body, bare-soil, etc, to be able to make a thorough evaluation of the effect of multi-spectral image compression in depth. The multi-spectral experimental images were compressed with JPEG-LS method. The principal result showed that with compression ratio 3:1, effects of multi-spectral image compression could be accepted for mapping application. Paul, Sujoy et al. [9] proposed a histogram based image compression based on multi-level image thresholding. The entropy function was maximized utilizing a popular metaheuristic named Differential Evolution to lessen the computational time and standard deviation of optimized objective value. Some images from popular image database of UC Berkeley and CMU were used as benchmark images. Important image quality metrics-PSNR, WPSNR and storage size of the compressed image file were employed for comparison and testing. Comparison of Shannon's entropy with Tsallis Entropy was also provided. Some specific applications of the proposed image compression algorithm were also pointed out. Vikrant Singh et al. [10] proved that imprecise situations can be properly handled using fuzzy logic. This feature of fuzzy logic has been incorporated by introducing a book data compression technique for gray images using fuzzy logic based fusion of available JPEG and JPEG2K Standards (FSHJPEG) to achieve higher compression ratio as compared to standalone JPEG and JPEG2K standards. The fuzzy based soft hybrid JPEG technique (FSHJPEG) gives high compression ratio, preserving nearly all of the image information and the image is reproduced with good quality. This new technique not only gives high compression ratio, but also reduces blocking artifacts, ringing effects and false contouring appreciably. The compression ratio obtained using FSHJPEG was more as compared to currently used standards of Image compression, preserving nearly all of the image information. Son, Thai Nam et al. [11] developed an efficient approach for a fractal image compression placed on a color image, which

utilizes a fractal coding on RGB to YUV color transformation at 4:1:1 sampling mode. The experimental results performed by Fisher's method for a color image have verified the likelihood to increase the compression ratio of FIC for color image while retaining an acceptable PSNR. It's purposed to design the low-bit-rate video encoding system by fractal coder/decoder of a color image. Rufai et al. [12] presented a new lossy image compression technique which uses singular value decomposition (SVD) and wavelet difference reduction (WDR). Both of these techniques are combined to ensure that the SVD compression to improve the performance of the WDR compression. SVD compression offers very high image quality but low compression ratios; on one other hand, WDR compression offers high compression. In the Proposed technique, an input image is first compressed using SVD and then compressed again using WDR. The WDR technique is further used to obtain the necessary compression ratio of the overall system.

### PROPOSED METHODOLOGY

This section contains the flow chart of the proposed algorithm. Figure 1 shows the different steps of required achieving the compression through proposed algorithm.



*Fig 1: Flowchart of the proposed algorithm*

Step 1: First of all input the image.

Step 2: Then fuzzy based soft hybrid jpeg techniques are applied on the input image.

Step 3: To apply gradient based optimization on output of step 2.

Step 4: To apply edge restoration.  
 Step 5: In this step, the image is compressed of step 4.  
 Step 6: Then, the parameters are evaluated.  
 Step 7: End of algorithm.

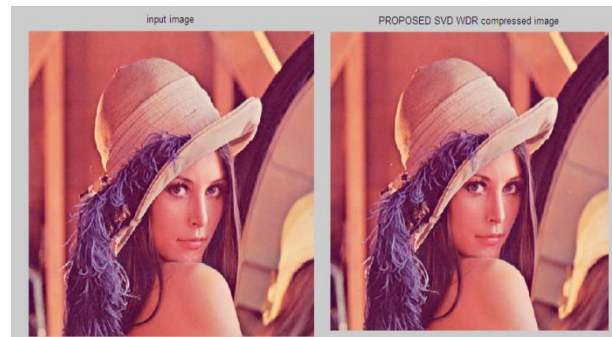
**RESULTS AND DISCUSSIONS**  
**EXPERIMENTAL IMAGES**



*Fig 2 : Input Image V/S Compressed Image Using SVD\_WDR*



*Figure 3 Input Image V/S Compressed Image Using SVD\_WDR Compression With Gradient-Based Optimization Approach*



*Figure 4 Input Image V/S Compressed Image Using Edge Restoration Method*

**PERFORMANCE EVALUATION**

*Table 1: Comparative analysis of LENA image*

Parameters	SVD_WDR	OBJECTIVE 1	OBJECTIVE 2
MSE	76	75	28
PSNR	29.26	29.3802	33.3802
SSIM	0.81	0.8727	0.8971

**CONCLUSION AND FUTURE SCOPE**

In this paper, a new compression technique has been proposed in which SVD-WDR compression has been integrated with Gradient-based optimization approach for reduction of blocking artifacts in images. The proposed algorithm has

been designed and implemented in MATLAB. The proposed technique has also been verified by using the various standard images for compression. The comparison will also be drawn among the proposed and the existing technique based upon the various standard quality metrics of the compression techniques.

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