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Study of Various Filtering Techniques, Genetic Algorithm and Fuzzy Logic for Reducing Blocking Artifacts in Compressed Images

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ABSTRACT: Blocking artifacts are the most common trouble creators for the image quality. They often declare their presence when image is compressed at low bit rates and are usually visible at the centre and at edges of the image. Discrete cosine transformation (DCT) is the most commonly used technique for image compression due to its accuracy and efficiency. During DCT image compression, blocking artifacts are observed at quantization process because of change in original values of DCT coefficients. Various studies have been made and a lot of filtering techniques than can be applied alone or with Genetic algorithm and fuzzy logic have been represented to significantly reduce these blocking artifacts. Some of these algorithms have better accuracy than others to reduce blocking artifacts at the image centre while some are good to reduce them at the edges. This paper is a study of various filtering techniques, genetic algorithm and Fuzzy logic that is effective in reducing blocking artifacts.

KEYWORDS: Artifact Reduction, Fuzzy Filtering, Filtering Techniques, Genetic Algorithm, Fuzzy Logic
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I.INTRODUCTION

Image compression is one of the most important tasks to make an image industry specific. Its primary objective is not just neglecting redundancy and irrelevance from an image but it is also effective in reducing the size an image needs for its storage in memory. Various lossy and lossless compression techniques are available for image compression and lossless techniques are preferred because of obvious reasons. Since last few years, discrete cosine transformation (DCT) is widely adopted method for image and video compression in many industries because of its efficiency and accurate results. Basically image is divided into 8×8 sub-blocks during DCT based compression.

This approach is good for high bit-rate compression but it suffers from blocking artifacts at low bit rate [1]. Artifacts declare their presence during quantization process and this is mainly because of change in original values of DCT coefficients. Due to the independent encoding of each block, visible discontinuities get emerged with block boundaries and this is exactly what that is called as blocking artifacts. As it's nothing but a trade-off among the coded image quality as well as bit rate, boosting coding bit rate results in improvement of quality of image reconstructed. However, it is bounded by bandwidth of channel. Thus there is a need of an approach to achieve bit rate that can neglect this problem without facing any issue from channel bandwidth. Various filtering techniques have been applied with Genetic algorithm and fuzzy logic for reducing blocking artifacts in compressed images. This paper spotlights some of the same.

II. LITERATURE STUDY

Image compression and reducing blocking artifacts from an image is a field towards which various researchers have made a lot of successful efforts. Many researchers have carried out several approaches that have successfully neglected the blocking artifacts up to an excellent extent. Some of these approaches in the form of Literature Survey are listed below.

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Motohide Yoshimura and Syunichiro, 1997 proposes a novel approach for edge detection for texture images with Genetic Algorithm. In the method proposed, edge detection problem is formulated as combinational optimization problem. Firstly the edge regions are elected and then GA is applied to decide the optimum edge regions. This paper represents an effective approach for arrangement of edge regions without spending a lot of time. Roberto Castango, and Giovanni Ramponi, 1998 proposed a very simple but highly effective methods for reduction of blocking artifacts. This method is based on Rational Filter. The method is basically expressed as a ratio among a polynomial and a linear function of input data. Filter is used for smoothing of artifacts that originated between two adjacent blocks. The best part about this filter is that it is capable of biasing its behavior which results in better performance. CI Wang, Wen-Jun Zhang and Xiang- Zhong, 2004 proposed an adaptive reduction method for blocking artifacts in DCT domain for highly compressed images. This paper basically proposed an algorithm for the blind measurement of the degree of blocking artifacts. To remove such discontinuities, a post-processing technology is approached. Entire task is operated in DCT domain. In the outcome they reduce blurring in objective edge and this is due to precision of edge detection by sobel operator is boosted by Walsh transform and local threshold technology. Adaptive smooth method and compensatory coefficients matrices are considered in deblocking to improve the post-processed performance of the image. A. Petrovski and T.Kartalov, 2006 represents a novel approach to cut down the blocking artifacts in block based DCT compression from images as well as video streams is discussed in this paper. Firstly the artifacts are measured in DCT domain and after that edge detection and adaptive processing of the image are the tasks which are performed in spatial domain.

III.FILTER TECHNIQUES

1. Rational Filter Approach: Rational Filter was carried out to perform edge-preserving noise smoothing. Its aim is to modulate the coefficients of a linear low pass filter in order to limit its action in presence of image details. It has been demonstrated that this operator, despite its simplicity, is able to outperform conventional methods for many noise distributions. Rational operators are formulated so that their input/output relation is the ratio of two polynomials in the input variables. Roughly speaking, the numerator has a low pass behaviour, while the denominator is a function of the difference between couples of pixels within the filtering mask; if this difference is large, it is assumed that the mask is located across a signal transition, and the frequency response of the low pass filter is automatically made less selective in the direction of the signal transition itself. To achieve a strong noise cancellation while still maintaining image details sharp, multiple filter passes can be performed. In fact, near a detail the multi-pass operation is similar to the one of a low pass filter having a large asymmetric mask covering only those pixels which has values similar to the one of the reference (central) pixel.

In the year 1998, Roberto Castagno, Stefan0 Marsi and Giovanni Ramponi represented a very effective approach. In their work a simple but very effective operator for reducing blocking artifacts was presented. The approach is based on Rational Filter approach. The filter is capable of biasing its behaviour in order to achieve best performance both in uniform areas, where linear smoothing is needed, and in textured zones, where nonlinear and directional filtering is considered as best. A detector of activity is embedded in the expression of the operator itself so that the biasing of the behaviour of filter is smooth and not based on fixed thresholds. In their work, a solution for the hardware implementation of the scheme is also presented. Despite the simplifications imposed by the hardware design, the filter retains the same efficiency as original algorithm. The rational operator proposed in their work is a quite simple one and operates on a **3** x **3** window, thus performing a mainly local action.

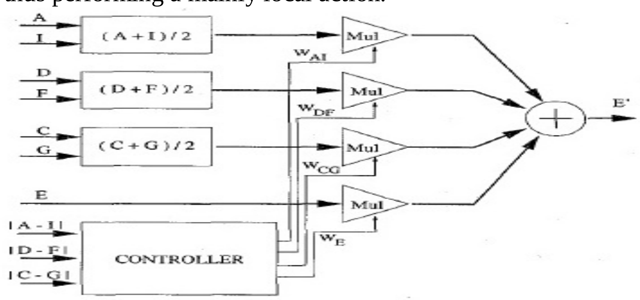

Fig. 1 Rational Filter proposed by Roberto Castagno, Stefan0 Marsi and Giovanni Ramponi

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2. An optimal L-filter for reducing blocking artifacts using genetic algorithms: An *L*-filter can be viewed as either a modification of a linear "nite impulse response (FIR) filter or a generalization of a median filter. Let $[x_1 \ldots . x_k]$ be a set of *k* observation data. If these data are arranged in increasing order according to their magnitude, the order statistics data becomes

$$x_{(1)} \leqslant x_{(2)} \leqslant \ldots \leqslant x_{(k)},$$

where $x_{(i)}$ represents the *i*th largest observation datum. Let ***x*** be a random vector; the entries of the random vector are ordered. The output signal *y* of ***x*** from an *L*-filter with filter window size *N* is defined as

$$y = \sum_{k=1}^{N} w_k x_{(k)} = w^{\mathrm{T}} x,$$

where $x = [x_{(1)} x_{(2)} \ldots x_{(N)}]^{\mathrm{T}}$, $w = [w_1 w_2 \ldots w_N]^{\mathrm{T}}$ is a weight vector and *w*s are called the filter coefficients, and *N* is an odd integer. From the definition, we can find that the median filter and mean filter are two special cases of the *L*-filter. The *L*-filter can be extended to process two-dimensional signals by considering the samples within the two-dimensional window as the values to be ranked and then linearly combined, regardless of the shape and size of the window. The filter coefficients should be constrained so that their sum is normalized to one for retaining the signal level.

An approach using an *L*-filter and a genetic algorithm to reduce blocking artifacts in compressed images was proposed by Chih-Chin Lai and Din-Chang Tseng in 2001. They view the blocking artifact removal as a de-noising problem since the blocking artifacts can be thought as the superposition of an image and a quantization noise. The proposed approach improves the visual quality of the de-blocked image without any modification on the compression and transmission procedures. The *L*-filter is an order statistic filter that has been used to remove different types of noises if the parameters of the *L*-filter are properly chosen. Since the parameter determination is an optimization problem, they use a GA [Genetic Algorithm] to search the proper parameters. The GA provides a systematic way to search the proper parameters and to produce proper *L*-filters for "filtering different characteristics of processed images. In order to improve the search performance of the GA, a new mutation operator considered the problem-dependent characteristic is also proposed. The proposed approach has the advantage of combining the powerful enhancement of the *L*-filter and the global solution exploration of the GA. In experiments, several other methods were also implemented for comparison. The experimental results reveal that the proposed approach is a practicable technique to reduce the blocking artifacts in the block-based compressed images.

3. Mean Square Error Filter in Wavelet Domain: Invented in the year 1960 in Stanford University, mean square error filter is nothing but a class of adaptive filter which are used to mimic a desired filter by finding the filter coefficients that relate to carrying out the least mean squares of error signal which is actually difference between the desired and the actual signal. It is a stochastic gradient descent method in that the filter is only adapted based on the error at the current time.

In 2003, Ick Hoon Jang Nam Chul Kim and Hyun Joo So proposed a very effective method which is based on the mean square error filter in the wavelet domain for blocking artifact reduction. They proposed an iterative algorithm for reducing the blocking artifact in block transform-coded images by using a minimum mean square error (MMSE) &lter in wavelet domain. An image is considered to be a set of one-dimensional (1-D) horizontal and vertical signals and a 1-D wavelet transform (WT) is utilized in which the mother wavelet is the first-order derivative of a Gaussian-like function.

Using an MMSE filter in the wavelet domain the blocking artifact is reduced by removing the component that causes the variance at the block boundary position in the first-scale wavelet domain to be abnormally high compared to those at the other positions and the variances at the positions near the block boundary position in the second-scale wavelet domain to be somewhat high. This filter minimizes the mean square error (MSE) between the ideal blocking component-free signal and the restored signal in the neighbourhood of block boundaries in the wavelet domain. The filter also uses local variance in the wavelet domain for pixel adaptive processing. The filtering and the projection onto a convex set of quantization constraint are performed alternately and iteratively. Their method provides not only a PSNR improvement but also a subjective quality that is nearly free of the blocking artifacts.

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4. A Localized DCT-based Filter: DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry, while in some variants the input and output data are shifted by half a sample. The DCT is used in JPEG image compression and MPEG. There, the two-dimensional DCT-II of **N×N** blocks is computed and the results are quantized and entropy coded.

In 2011, Dung T.V.and Truong Q. Nguyen proposed a new approach for coding artifact reduction in the compressed images [Fig. 2]. In their work, they considered a localized filter based on DCT with condition on the similarity among surrounding blocks for reducing blocking artifacts. To reduce ringing, a localized fuzzy filter is considered to neglect the blurry effect of linear filter and painting-like effect of conventional fuzzy filter. In their work, to improve chroma components and to avoid the colour bleeding, the localized filter for luma component is implemented for chroma components.

For image enhancement, a condition of small difference among the block of interest and the spatially surrounding blocks was implemented by them as follows:

$$\sum_{m=0}^{N-1}\sum_{n=0}^{N-1}\left|Y_q(m+m_i,n+n_i)-Y_q(m,n)\right|\leq Th$$

where Th *is a threshold*

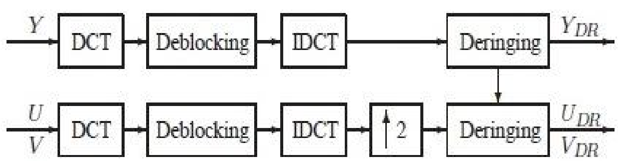

Fig. 2 Algorithm proposed by Dung T.V.and Truong Q. Nguyen

5. Adaptive Fuzzy Filtering Approach*:* In 2011, Ehsan Nadernejad, Søren Forchhammer, and Jari Korhonen proposed an effective algorithm for image and video artifact removal using an adaptive fuzzy filter and directional anisotropic diffusion. Before you consider this approach, it's good to read about Fuzzy filters discussed in Section III.

This novel method overcomes the limitations of the conventional nonlinear filters by taking pixel's activity and the direction between pixels both into account. It has been shown by them that the proposed algorithm improves the visual quality of compressed images and videos in terms of *PSNR* and *MSSIM*, compared to few existing approaches. Their proposed adaptive scheme can be applied to different image and video compression standards, such as *JPEG, MJPEG* and *H.264.*

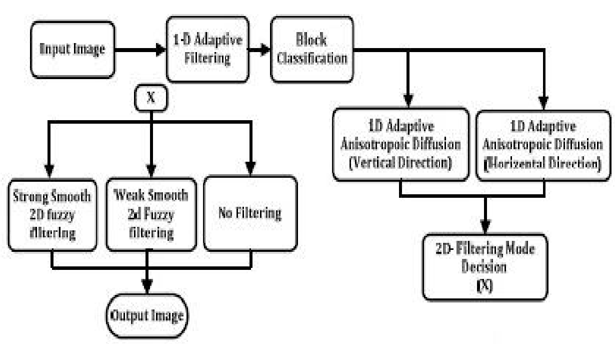

Fig. 3 Method proposed by Ehsan Nadernejad, Søren Forchhammer, and Jari Korhonen

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In this method basically adaptive 1-D fuzzy filtering is first applied to the pixels suffering from blocking artifacts, and then directional anisotropic diffusion is used to increase the quality. Finally, adaptive 2-D fuzzy filtering is applied to the pixels with ringing artifacts. In the first phase, vertical artifact detection is performed along each vertical boundary of an 8x8 block. For this purpose, the difference between each pair of boundary pixels is computed. Similar analysis was also performed by them horizontally.

In addition to all above, a new adaptive post-filtering algorithm is proposed by *Seydi Kaçmaz, Sema Koç Kayhan, Ergun Erçelebi* in 2012 to remove observed blocking artifacts as a result of discrete cosine transform (DCT) based image and video compression standards at low bit rates. With identification of blocking artifact strength, fuzzy filter is applied by adjusting filtering range and its parameters. Their experimental results showed that, the algorithm proposed by them exhibits better detail preservation and artifact removal performance with lower computational cost as compared to other post-processing techniques. Check [6]

IV.**OVERVIEW OF OTHER FILTERING TECHNIQUES**

1. Spatial Filtering*:* Spatial filtering is a term used to describe the methods used to compute spatial density estimates for events observed at individual locations. Spatial prediction does not out-perform pure DCT based technique in terms of bit-rate tradeoff. At very low bit rates it results in far fewer blocky artifacts and better visual quality. It describes a set of tools for displaying functions estimated from these data points that are distributed in two-dimensional space. This method used a two-dimensional filter in the areas away from edges, and for near edges, one-dimensional filter aligned parallel to edge so as to minimize the blocking artifacts.

2. Hybrid Filtering: Hybrid filtering technique tries to combine both the methods discussed above. It does not require IDCT; its implementation in hardware becomes easy. Due to the significant reduction of the ringing effect, this method yields better performance in terms of both objective and subjective views than the other methods. This method of hybrid approach is applied to the blocks with vertical or horizontal edge. It is said to improve processing speed, suppress speckle and enhance edges.

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V.FUZZY FILTERS

Fuzzy filters improve the median filters or rank condition rank selection filters by replacing the binary spatialrank relation by a real-valued relation. Fuzzy filter is defined by generalizing the binary spatial-rank relation. Assuming that filter *h* is applied to a set ω of neighbouring samples $f(i+i',j+j')$ around the input $f(i,j)$, output can be formulated as:

$$g[i,j] = \sum_{[i',j']} h(f[i+i',j+j'], f[i,j]) \times f[i+i',j+j']$$

The unbiased form by normalization of the above equation is given by:

$$g[i,j] = \frac{\sum_{[i',j']\in\omega} h(f[i+i',j+j'], f[i,j])\, f[i+i',j+j']}{\sum_{[i',j']\in\omega} h(f[i+i',j+j'], f[i,j])}$$

where $h(f[i+i',j+j'],f[i,j])$ controls the contribution of the input $f[i+i',j+j']$ to the output. Due to the input independence of the filter coefficients, a low-pass filter designed to perform effectively in the flat areas may introduce blurring artifacts in the detailed areas. However, it is desirable to preserve the details, while removing the artifacts. This can be achieved by imposing constraints, such as if $f[i+i',j+j']$ is far from $f[i,j]$, its contribution to the output is small. In this case, the filter coefficients $h[i,j]$ must follow the constraints

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$$\lim_{|f[i+i',j+j']-f[i,j]|\to 0} h(f[i+i',j+j'],f[i,j]) = 1$$
$$\lim_{|f[i+i',j+j']-f[i,j]|\to \infty} h(f[i+i',j+j'],f[i,j]) = 0$$
$$h(f[i+i_1',j+j_1'],f[i,j]) \ge h(f[i+i_2',j+j_2'],f[i,j])$$
$$if\ \left|f[i+i_1',j+j_1']-f[i,j]\right| \le \left|f[i+i_2',j+j_2']-f[i,j]\right|,$$

The function $h(f[i+i',j+j'],f[i,j])$ is called a membership function, and there are many functions that fulfil these requirements. A Gaussian membership function is given in:

$$h(f[i+i',j+j'],f[i,j]) = \exp(-\frac{(f[i+i',j+j']-f[i,j])^2}{2\sigma^2}),$$

where σ represents the spread parameter of the input and controls the strength of the fuzzy filter. The input $x[i,j]$ contributes the output always more that the other samples:

$$h(f[i,j],f[i,j]) \ge h(f[i+i',j+j'],f[i,j])\ \forall k$$

For the same $|f[i+i',j+j']-f[i,j]|$, the higher the value of σ, the higher the contribution of $f[i+i',j+j']$ to the output. This implies that $f[i,j]$ will converge more towards $f[i+i',j+j']$. Smaller values of σ will keep the signal $f[i,j]$ more isolated from its neighbouring samples. The spread parameter should be adaptive to different areas with different activity levels, such as smooth or detailed textures. The conventional fuzzy filter uses fixed spread parameters for every surrounding sample, ignoring their relative positions. In image and video compression, distortions such as blocking, ringing or flickering artifacts are directional, and, thus, the direction between $f[i,j]$ and its surrounding samples $f[i+i',j+j']$ should be taken into consideration. This can be achieved by an adaptive spread parameter:

$$\sigma(f[i+i',j+j'],f[i,j]) = K[i,i',j,j'] \times \sigma_A[i,j]$$

where σA is a position-dependent amplitude function of the spread parameter, and K is the scaling function controlled by the direction of $[i+i',j+j']$ to $[i,j]$. More useful information on Fuzzy Filters is available in [3] and [4]

VI. GENETIC ALGORITHM

1. General Introduction*:* Before you introduce yourself with Genetic Algorithm, it’s important to know that one of the leading problem with Genetic Algorithm is its time consumption. Many times it takes a lot of time for results to declare their presence. This is mainly because GA is not a solution which is mathematically guided for solving a problem. It is basically a highly dimensional, discrete and non-liner search algorithm. Before consideration of GA in practical applications, (especially in Image processing and signal processing), issue of computing overrun time needs more attention before it can be resolved.[9]

GA was first used by J.H. Holland in the year 1970. His work was an excellent contributor for scientific and engineering problem solving. Since then, the output of research work in this field has grown exponentially although the contributions have been, and are largely initiated, from academic institutions world-wide. It is only very recently that we have been able to acquire some material that comes from industry. The concept of this is somehow not clearly understood. However, the obvious obstacle that may drive engineers away from using GA is the difficulty of speeding up the computational process, as well as the intrinsic nature of randomness that leads to a problem of performance assurance. Nevertheless, GA development has now reached a stage of maturity, thanks to the effort made in the last few years by academics and engineers all over the world. It has blossomed rapidly due to the easy availability of low-cost but fast speed small computers. Those problems once considered to be “hard” or even “impossible,” in the past are no longer a problem as far as computation is concerned. Therefore, complex and conflicting problems that require simultaneous solutions, which in the past were considered deadlocked problems, can now be obtained with GA. Furthermore, the GA is not considered a mathematically guided algorithm. The optima obtained is evolved from generation to generation without stringent mathematical formulation such as the traditional gradient-type of optimizing procedure. In fact, CA is much different in that context. It is merely a stochastic, discrete event and a nonlinear process. The obtained optima is an end product containing the best elements of previous generations where the attributes of a stronger individual tend to be carried forward into the following generation. The rule of the game is "survival of the fittest will win."

2. Basic Concepts*:* The basic principles of GA were first proposed by Holland. Thereafter, a series of literature and reports became available. GA is inspired by the mechanism of natural selection, a biological process in which stronger individuals are likely be the winners in a competing environment, Here, GA uses a direct analogy of such natural evolution. It presumes that the potential solution of a problem is an individual and can be represented by a set of parameters. These parameters are regarded as the genes of a chromosome and can be structured by a string of values in binary form. A positive value, generally known as fitness value, is used to reflect the degree of "goodness" of the chromosome for solving the problem, and this value is closely related to its objective value.

Throughout a genetic evolution, a fitter cliromosome has the tendency to yield good-quality offspring, which means a better solution to the problem. In a practical application of GA, a population pool of chromosomes has to be installed and they can be randomly set initially. The size of this population varies from one problem to the other. In each cycle of genetic operation, termed an evolving process, a subsequent generation is created from the chromosomes in the current population. This can only be successful if a group of those chromosomes, generally called "parents" or a collection term "mating pool," are selected via a specific selection routine. The genes of the parents are to be mixed and recombined for the production of offspring in the next generation. It is expected that from this process of evolution (manipulation of genes), the "better" chromosome will create a larger number of offspring, and thus has a higher chance of surviving in the subsequent generation, emulating the survival-of-the-fittest mechanism in nature. **A** scheme called roulette wheel selection is one of the most commonly used techniques in such a proportionate selection mechanism.

The cycle of evolution is repeated until a desired termination criterion is reached. This criterion can also be set by the number of evolution cycles (computational runs), the amount of variation of individuals between different generations, or a pre-defined value of fitness. In order to facilitate the GA evolution cycle, two fundamental operators-crossover and mutation-are required.

VI.CONCLUSION

Prior knowledge always play a significant role in carrying out new approaches in any field and so does on removing blocking artifacts in an image. This paper assist readers to know and understand the best filtering techniques applied so far for reducing blocking artifacts. Fuzzy filter and Genetic Algorithm is also explained in this paper which in fact are having tremendous applications in reducing blocking artifacts from an image.

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BIOGRAPHY

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