DESIGN OF DEBLOCKING FILTER IN VIDEO CODING

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report **“DESIGN OF DEBLOCKING FILTER IN VIDEO CODING”** is the bonafide work of **“SADWIN BRUNAS D (810015104078)** and **SUTHAN M (810015104095)”** who carried out the project work under my supervision.

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DECLARATION

We hereby declare that the work entitled "**DESIGN OF DEBLOCKING FILTER IN VIDEO CODING**" is submitted in partial fulfillment of the requirement for the award of the degree in B.E, in University College of Engineering, BIT Campus, Anna University, Tiruchirappalli. It is the record of our own work carried out during the academic year 2017 – 2018 under the supervision and guidance of **Dr.R. KRISHNAMOORTHY**, Professor, Department of Information Technology, University College of Engineering, BIT Campus, Anna University, Tiruchirappalli. The extent and source of information are derived from the existing literature and have been indicated through the dissertation at the appropriate places.

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ABSTRACT

Over the last one and a half decades, the growth of multimedia is rapid, which influences more memory storage for devices to store. Therefore, Compression plays a significant role by reducing the data redundancy and to save more space. Thus, digital video compression technologies have become an integral part of the way we create, communicate, and consume visual information. As a result, there occurs a visible discontinuity along the block boundary due to low bit rate quantization.

In this project, we propose a design for the deblocking filter which enhances the quality of the video. A deblocking filter is applied to decoded compressed image to improve visual quality and prediction performance by removing the blocky noise which can form between macroblocks, where block coding techniques are used. The filter aims to improve the appearance of decoded pictures.

Therefore, the goal of this deblocking filter is to remove blocking artifacts that exist at macroblock boundaries. However, due to complexity of deblocking algorithm, the filter can easily account for one-third of the computational complexity of a decoder.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

OPT	-	Orthogonal Polynomials Transformation
DCT	-	Discrete Cosine Transformation
BDCT	-	Block-based Discrete Cosine Transform
FISTA	-	Fast Iterative Shrinkage/Thresholding Algorithm
BBTC	-	Block Based Transformation Coding
RLE	-	Run-Length Encoding
EOF	-	End of File
MSE	-	Mean Square Error
PSNR	-	Peak Signal to Noise Ratio

CHAPTER-1

INTRODUCTION

1.1 OVERVIEW

Recently multimedia plays an important role in almost every sector. The H.265 is the recent encoding format for the video encoding, where the storage is high. Therefore, compression plays a significant role by reducing the data redundancy and to save more space. Thus, digital video compression technologies have become an integral part of the way we create, communicate, and consume visible discontinuity, motion compensation and block-based transformation.

Quantization is the important factor for image compression. When the image is compressed with high quality factor, noticeable block defects commonly known as Block Artifact is visible in the decoded compressed image. Block Artifact is a common problem in image coding and video coding based on most of the transformation coding techniques.

1.2 BENEFITS

There are some benefits that encourage researchers to focus on the video compression. These are:

- Memory space is saved.
- Block artifact is reduced.

- It not only reduces the redundancy but also increases the efficiency.

Even though the compression reduces the quality factor, with block defect in this project we are increasing the quality with reducing the block defect of image

The extraction of features from the image may correspond to extraction of Edge and Texture component from the image. For extraction of texture component and Structure component, Various algorithm are used. In this thesis, the mathematical transformation taken to extracting image feature is Orthogonal Polynomials Transformation (OPT).

As a general summarization, OPT has the advantage of less computational complexity and encouraging performance.

1.3 OBJECTIVES OF THE PROJECT WORK

The project aims to

- Reduce the storage space by compressing the image.
- Reduce the block defect of compressed image.

To increase the image quality of compressed image by reducing block defect of an image, thus block defect is reduced by extracting low level feature of the image and applying weighted average block filter, where texture component consists of small oscillating signals and noise. Moreover, encoding in OPT domain for efficient processing decreases the time complexity with satisfactory performance.

1.4 CONTRIBUTION TO THE PROJECT WORK

In this project work, frames are extracted from the original video and the extracted frames are compressed with high quality factor. Thus, the compressed frames seem to have block artifact. The compressed frames are then subjected to extract the texture component using OPT. The texture component is feeded into the Weighted average block filter. After these processes the image is received with reduced blocking artifact. This process is continued for all frames extracted from standard videos. It then Converts the total number of processed frames back to the video.

1.5 ORGANIZATION OF THE REPORT

The report is organized into eight chapters. In chapter 2, related literature survey concerning the project has been discussed. Chapter 3 presents the modules of the system design. Chapter 4 explains the mathematical preliminaries of Orthogonal Polynomials Transformation. In chapter 5, the proposed system for the video coding is described in detail with the architectural model of phase I. In chapter 6, the proposed system of deblocking filter is described in detail with architectural model of phase II and the performance measures. In chapter 7, various experimental results are analyzed and presented. Finally, the conclusion is drawn in chapter 8.

CHAPTER–2

LITERATURE SURVEY

When it comes to Video coding many researchers have proposed various techniques to overcome the defect. In order to gather idea about the existing systems, various literatures on deblocking filter has been studied. There are many steps involved in designing a deblocking filter for the video coding, starting from the separation of frames to removal of the blocky noise of the image.

The technique of frame compression coding as stated by Thomas Wiegand et. al [1] includes compression, transformation, quantization, encoding and deblocking. This states the overview of the technical features of standard video compression and describes profiles and applications for the standard besides outlining the history of the standardization process.

The compression artifact reduction technique based on Total Variation Regularization was proposed by T. Kariyazaki, T. Goto, S. Hirano and M. Sakurai [2] for the reduction of blocky noise of the image using the DCT features of the image in frequency domain.

A. Kaup [3] describes the reduction of the ringing noise of the image in transformed domain using simple adaptive filter for the purpose of denoising the ringing around the edges of the image.

The method of image feature extraction using a generalized TV Regularization filtering for improving the quality of the frame in the video with the motion estimated block for the video signal processing is reported in [4] by C. Dolar, M. M. Richter and H. Schroder.

The methodology of edge preserving smoothing filter is proposed by Ying Luo and Rabab K. Ward [5] for the purpose of determining the correlation between the neighboring blocks to reduce the discontinuity of the pixels across the boundaries. Thereby reducing the block artifact by preserving block boundary.

In the paper by Kiryung Lee, Dong Sik Kim and Taejeong Kim [6] an adaptive enhancement for the image enables an appropriate blurring depending on the smooth or detail region, and shows improved performance in terms of the average distortion and the perceptual view.

Krishnamoorthy et. al [8] described transform coding of images with Orthogonal Polynomials coefficients which was proved to be efficient and the same was described with improved performance in Krishnamoorthy [8] for monochrome model.

A. Chambolle [9] an alternative way for the removal of the block artifact by using some of the ways to minimize the total variation of an image using some of the applications like image denoising, zooming, and the computation of the mean curvature motion of interfaces.

Jongho Kim and Chun-Bo Sim [10] introduced a way of reducing the blocking noise of the image by a Block-based Discrete Cosine Transform (BDCT) where the annoying noisy signals of the image is being truncated by a technique known as Signal Adaptive Weighted Sum (SAWS) to alleviate the blocking artifacts encountered in the highly compressed images.

The ITU-T Recommendation H.263 [11] proposed a low bit rate video coding technique in which a preferable Annex J method of deblocking edge filter makes the removal of block artifact using an optimal block edge filter utilizing the motion vectors for the frame.

The idea described by A. Beck and M. Teboulle [12] makes use of steepest descent method (Gradient descent method) based algorithm for denoising the image and enhancement, known as fast gradient-based algorithm. It also includes technique to overcome the deblurring effect with a novel monotone version of a

Fast-Iterative Shrinkage/Thresholding Algorithm (FISTA).

G R Poornima, S C Prasanna Kumar and S Ramachandran [13] proposed an in-loop filtering algorithm which is used to reduce the blocking distortions. The blocking distortions damages the quality of the image during compression process. Blocking distortions are the discontinuities created at the block boundaries

The different techniques used to design the proposed system have been reviewed in literature and its usefulness to design overall system concept is described in the subsequent chapters.

CHAPTER-3

SYSTEM DESIGN

3.1 OVERVIEW

This chapter describes the system architectural design of the proposed work, describing various stages involved in it. The architecture diagram of the proposed system is presented in two phases.

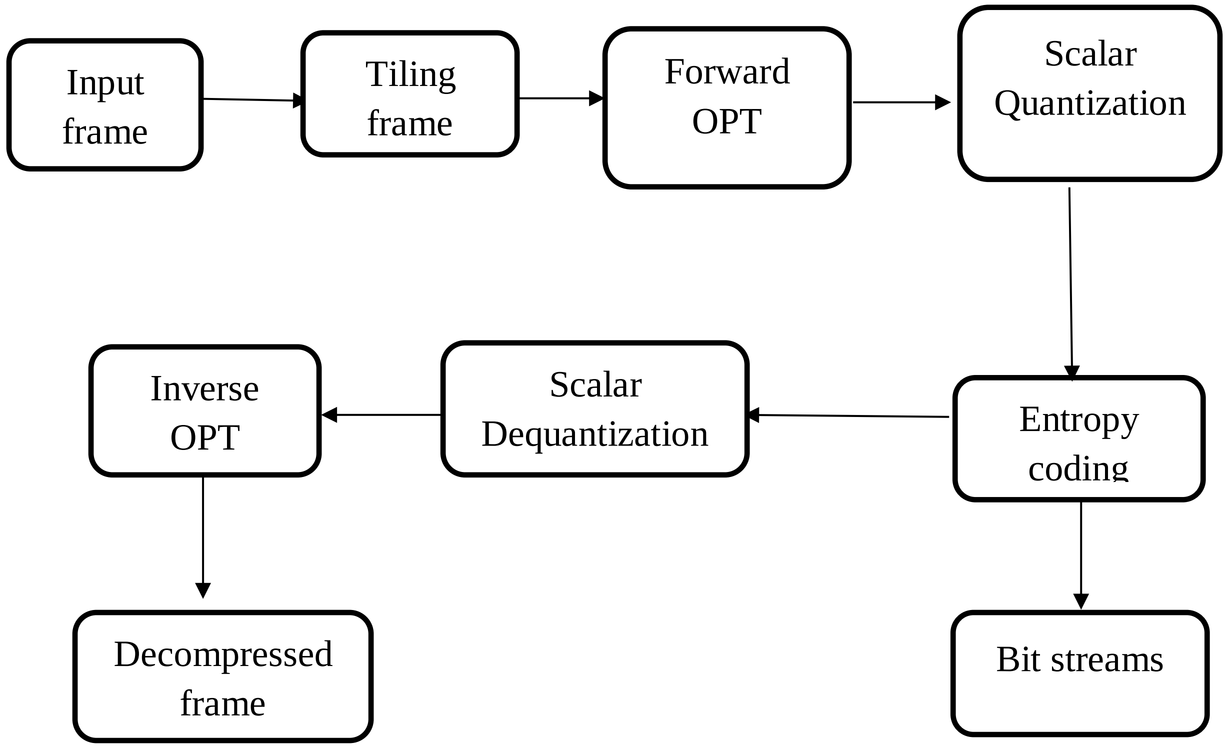

FIGURE 3.1 Phase I: Architecture diagram for Video Coding

In phase 1, the compression of video frame is carried out after extracting frames from video. The frames from video tilled is occur to separate the frames in block for further process. Here the tilled occur in the format 3X3.

3.2 SYSTEM ANALYSIS

3.2.1 FORWARD TRANSFORMATION

Transformation is the process of converting correlated value into uncorrelated value. OPT transformation is carried. OPT transformation is explained in detail in chapter 4. It is used as it has described that there is a correlation between each values of the color i.e.) RGB values. Also, used to convert from spatial domain to frequency domain.

3.2.2 QUANTIZATION

Quantization, involved in image processing, is a lossy compression technique achieved by compressing a range of values to a single quantum value. When the number of discrete symbols in a given stream is reduced, the stream becomes more compressible.

3.2.3 ENTROPY CODING

Entropy coding is a lossless data compression scheme that is independent of the specific characteristics of the medium. These entropy encoders then compress data by replacing each fixed-length input symbol with the corresponding variable-length prefix-free output codeword.

3.2.3 INVERSE TRANSFORMATION

Inverse OPT is the process of reconstruction of pixel values. Inverse OPT is explained detail in chapter 4. It is used for converting frequency domain values to spatial domain.

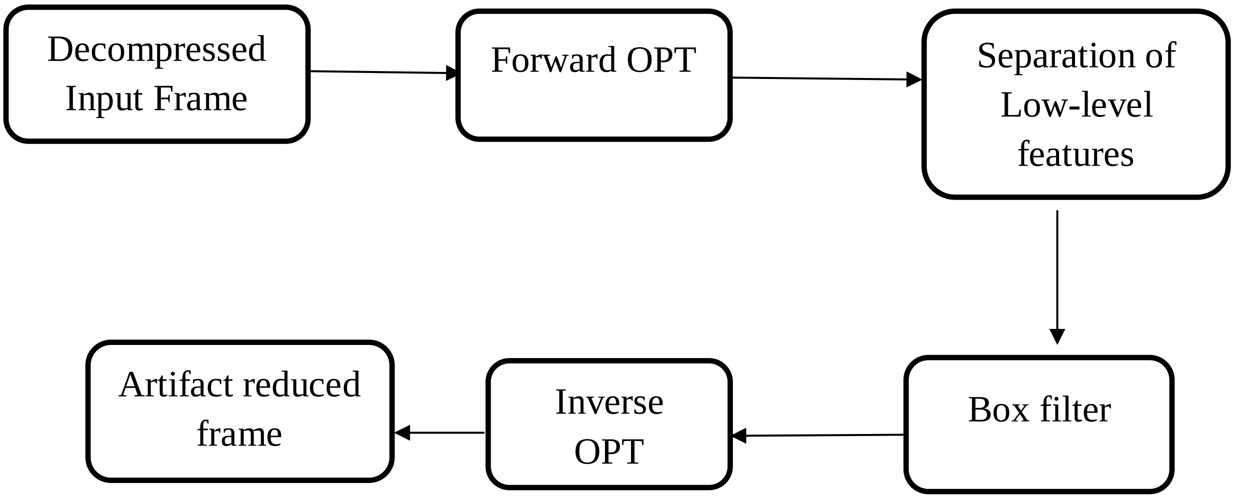

FIGURE 3.2 Phase II: Architecture diagram for Deblocking filter.

3.2.4 SEPARATION OF LOW-LEVEL FEATURES

After the forward OPT transformation is applied, low level features are separated using OPT as described in chapter 4. Low level features are edges, texture, smoothing signal, etc. Weighted Average Block Filter is applied to extracted low level features using OPT. These values of the edges and texture from the extracted frame may correspond to some abrupt changes in the values between the pixels. Thus, used for extraction of features from the frame.

3.2.5 BOX FILTER

The Box filter is an averaging filter and is used to normalize the values of a block by using an averaging method. Thus, each pixel in the resulting image has a value equal to the average value of its neighboring pixels in the input image.

3.3 SYSTEM ENVIRONMENT

3.3.1 Hardware

Processor: Any Processor above 1.2 GHz

RAM: 128 MB and above

Hard Disk: 10 GB

Input Device: Standard Keyboard, Mouse

Output Device: VGA Monitor 3.3.2

Software Front-End: Java

IDE: Eclipse Java Oxygen

External Jar: jcodec 0.1.6-3

3.3.2 Software

Front-End: Java

IDE: Eclipse Java Oxygen

External Jar: jcodec 0.1.6-3

CHAPTER-4

MATHEMATICAL PRELIMINARIES ON ORTHOGONAL POLYNOMIALS

4.1 INTRODUCTION

The proposed work utilizes orthogonal polynomials model coefficients for finding motion vectors in video compression. As orthogonal polynomials transformation is reported be a suitable transformation for image compression and related tasks, it is adopted for the design of the proposed video deblocking scheme. Hence, a brief overview of mathematical preliminary on orthogonal polynomials model for the grey scale domain is presented in this chapter.

In general, image processing operations are carried out either in spatial or frequency domain. In the spatial domain, the original pixel values of the image are found to be correlated and hence the estimation of motion vectors is reported to be difficult to calculate. Alternatively, the techniques based on frequency transformation have been developed to handle these issues efficiently with only a few transform coefficients. The use of such a transformation obtained with orthogonal polynomials is highlighted in this project work for video deblocking. A brief description of orthogonal polynomials model is presented in this next section.

4.2 ORTHOGONAL POLYNOMIALS MODEL

In recent years, the design of orthogonal polynomials model is widely utilized in image processing algorithms as it is reported to have higher efficiency.

Hence, in this project work, a modified deblocking filter with orthogonal polynomials transformation is proposed.

For the purpose of image formation system, a linear two-dimensional image formation system [8] is considered around a Cartesian coordinate separable, blurring, point spread operator in which the image *I* results in the superposition of the point source of impulse weighted by the value of the object function *f*. Expressing the object function *f* in terms of derivatives of the image function I relative to its Cartesian coordinates are very useful for analyzing the image. The point spread function $M(x, y)$ can be considered to be real valued function defined for $(x, y) \in X \times Y$, where *X* and *Y* are ordered subsets of real values. In case of gray-level image of size (n x n) where *X* (rows) consists of a finite set, which for convenience can be labeled as $\{0, 1, \ldots, n\text{-}1\}$, the function $M(x, y)$ reduces to a sequence of functions.

$$M(i, t) = u_i(t), \quad i = 0, 1, \ldots, n\text{-}1 \tag{4.1}$$

The linear two-dimensional transformation can be defined by the point spread operator $M(x, y)$ ($M(i, t) = u_i(t)$) as shown in Equation (4.2).

$$\beta'(\zeta,\eta) = \int_{x\in X}\int_{y\in Y} M(\zeta,x)M(\eta,y)I(x,y)\,dx\,dy \tag{4.2}$$

Considering both *X* and *Y* to be a finite set of values $\{0, 1, 2, \ldots, n-1\}$, Equation (4.2) can be written in matrix notation as follows

$$|\beta'_{ij}| = (|M| \otimes |M|)^t |I| \tag{4.3}$$

where $\otimes$ is the outer product, $|\beta'_{ij}|$ are n^2 matrices arranged in the dictionary sequence, $|I|$ is the image, $|\beta'_{ij}|$ are the coefficients of transformation and the point spread operator $|M|$ is

$$|M| = \begin{vmatrix} u_0(t_0) & u_1(t_0) & \cdots & u_{n-1}(t_0) \\ u_0(t_1) & u_1(t_1) & \cdots & u_{n-1}(t_1) \\ & & \vdots & \\ u_0(t_{n-1}) & u_1(t_{n-1}) & \cdots & u_{n-1}(t_{n-1}) \end{vmatrix} \tag{4.4}$$

We consider a set of orthogonal polynomials $u_0(t)$, $u_1(t)$, …, $u_{n-1}(t)$ of degrees 0, 1, 2, …, n-1 respectively to construct the polynomial operators of different sizes from Equation (4.3) for $n \geq 2$ and $t_i = i+1$. The generating formula for the polynomials is as follows.

$$u_{i+1}(t) = (t-\mu)\, u_i(t) - b_i(n)\, u_{i-1}(t)\,, \text{ for } i \geq 1 \tag{4.5}$$

$u_1(t) = t - \mu$, and $u_0(t) = 1$,

where $b_i(n) = \dfrac{\langle u_i, u_i \rangle}{\langle u_{i-1}, u_{i-1} \rangle} = \dfrac{\sum_{t=1}^{n} u_i^2(t)}{\sum_{t=1}^{n} u_{i-1}^2(t)}$ and $\mu = \dfrac{1}{n}\sum_{t=1}^{n} t$

Considering the range of values of t to be $t_i = i$, i = 1, 2, 3, …, n, we get

$$b_i(n) = \frac{i^2\left(n^2 - i^2\right)}{4\left(4i^2 - 1\right)}, \qquad \mu = \frac{1}{n}\sum_{t=1}^{n} t = \frac{n+1}{2}$$

We can construct point-spread operators $|M|$ of different size from Equation (4.4) using the above orthogonal polynomials for $n \geq 2$ and $t_i = i$. For the convenience of point-spread operations, the elements of $|M|$ are scaled to make them integers.

4.3 DIFFERENCE AND BASIS OPERATORS

For the sake of computational simplicity, the finite Cartesian coordinate set X, Y is labelled as {1, 2, 3}. The point spread operator can be obtained as $|M| \otimes |M|$, where $|M|$ can be computed and scaled as follows.

$$|M| = \begin{vmatrix} u_0(t_0) & u_1(t_0) & u_2(t_0) \\ u_0(t_1) & u_1(t_1) & u_2(t_1) \\ u_0(t_2) & u_1(t_2) & u_2(t_2) \end{vmatrix} = \begin{vmatrix} 1 & -1 & 1 \\ 1 & 0 & -2 \\ 1 & 1 & 1 \end{vmatrix}$$

The set of polynomial basis operators O_{ij}^{n} ($0 \leq i, j \leq n-1$) can be computed as

$$O_{ij}{}^{n} = \hat{u}_i \otimes \hat{u}_j$$

where $\hat{u}_i$ is the $(i+1)^{1st}$ column vector of $|M|$.

The complete set of basis operators of sizes (2 x 2) and (3 x 3) are given below.

Polynomial basis operators of size (2 x 2) are

$$\left[O_{00}^{2}\right] = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}, \left[O_{01}^{2}\right] = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}, \left[O_{10}^{2}\right] = \begin{bmatrix} -1 & -1 \\ 1 & 1 \end{bmatrix}, \left[O_{11}^{2}\right] = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

Polynomial basis operators of (3 x 3) are

$$[O_{00}^3]=\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix},\quad [O_{01}^3]=\begin{bmatrix}-1 & 0 & 1\\ -1 & 0 & 1\\ -1 & 0 & 1\end{bmatrix},\quad [O_{02}^3]=\begin{bmatrix}1 & -2 & 1\\ 1 & -2 & 1\\ 1 & -2 & 1\end{bmatrix}$$

$$[O_{10}^3]=\begin{bmatrix}-1 & -1 & -1\\ 0 & 0 & 0\\ 1 & 1 & 1\end{bmatrix},\quad [O_{11}^3]=\begin{bmatrix}1 & 0 & -1\\ 0 & 0 & 0\\ -1 & 0 & 1\end{bmatrix},\quad [O_{12}^3]=\begin{bmatrix}-1 & 2 & -1\\ 0 & 0 & 0\\ 1 & -2 & 1\end{bmatrix}$$

$$[O_{20}^3]=\begin{bmatrix}1 & 1 & 1\\ -2 & -2 & -2\\ 1 & 0 & 1\end{bmatrix},\quad [O_{21}^3]=\begin{bmatrix}-1 & 0 & 1\\ 2 & 0 & -2\\ -1 & 0 & 1\end{bmatrix},\quad [O_{22}^3]=\begin{bmatrix}1 & -2 & 1\\ -2 & 4 & -2\\ 1 & -2 & 1\end{bmatrix}$$

where 2-D point-spread operator defined as $|M| = |M \otimes M|$.

Having described the summary of orthogonal polynomials transformation, the utilization of the same for the purpose of motion estimation and compensation for video compression is presented in the next chapter.

CHAPTER-5

PHASE I: VIDEO CODING TECHNIQUE

Many techniques for video coding have been proposed so far in many fields. In this proposed work of video coding we made use of Block Based Transformation Coding (BBTC) which comprises of a block-based transformation technique for encoding and decoding a frame of the video. Thus, Orthogonal Polynomial Transformation (OPT) is a transform coding which is used for transforming the spatial domain values to frequency domain and vice versa. The steps involved is described as follows:

1. RGB separation
2. Encoding process
3. Entropy Coding
4. Decoding process

5.1 RGB SEPARATION

The video to be encoded is partitioned into separated frames for evaluation and is subjected to separation process for the transform coding. Then each frame is evaluated for the RGB extraction where they can be used to process the Orthogonal Polynomial Transformation (OPT) as they have the following pros:

- There is some correlation between each color values of RGB.
- Orthogonal Polynomial Transformation (OPT) makes use of this correlated color values and performs the transformation.
- By using this transformation there comes a less removal of detailing

and a quality of the decoded image would be retained again.

5.2 ENCODING PROCESS

5.2.1 FORWARD TRANSFORMATION

After the extraction of the RGB color values from the frame, there is an important step in image processing known as Tile formation. The image of any size is divided into (m x n) equal sized blocks. This is mainly done for the reason that the processing of image in terms of blocks is simple and in addition to that, the process can be repeated for each and every block in the frame iteratively.

After the Tile formation, the spatial domain values of the frame are transformed into frequency domain. This transformation is necessary as it has the following facts to be taken into account:

- Every process in video coding can be continued in same domain, i.e., frequency domain.
- It is assumed that the accuracy in frequency domain is better than spatial domain.
- Efficiency can be improved as all the processes are carried out in the same domain.

The transformation used in this technique of deblocking filter is Orthogonal Polynomial Transformation (OPT). The OPT coefficients are obtained for each tile as described in chapter 4 and the OPT coefficients of each tile is stored for processing.

5.2.2 SCALAR QUANTIZATION

The quantization is a lossy compression technique achieved by compressing a range of values to a single quantum value. When the number of discrete symbols in a given coefficients is reduced, they become more compressible. This quantization is done by simply dividing each component in the frequency domain by a constant for that component, and then rounding to the nearest integer. This is the main lossy operation in the whole process. As a result of this, it is typically the case that many of the higher frequency components are rounded to zero, and many of the rest become small positive or negative numbers.

$$\mathrm{V}\ (\mathrm{x},\ \mathrm{y}) = \left\lfloor \frac{|U\ (x,y)|}{\Delta} \right\rfloor * sgn(\ U\ (x,y))$$

Where U (x, y) represents input sub-band coefficient, V (x, y) represents output quantized coefficient and Δ represents quantizer step size.

5.2.3 ENTROPY CODING

5.2.3.1 RUN LENGTH CODING

Run-Length Encoding (RLE) is a very simple form of lossless data compression in which runs of data are stored as a single data value and count, rather than as the original run. This is most useful on data that contains many such runs.

If there are more leading zeros then it is denoted as EOF (End of File). Thus, RLE algorithms cannot achieve the high compression ratios of the more advanced compression methods, RLE is both easy to implement and quick to execute, making it a good alternative to either using a complex compression algorithm or leaving the image data uncompressed. This is given as:

Original data stream: 17 8 54 0 0 0 97 5 16 0 45 23 0 0 0 0 3 67 0 0 0 0 0 0 0………

Run-length encoded: 17 8 54 0 3 97 5 16 0 1 45 23 0 4 3 67 EOF

5.2.3.2 HUFFMAN CODING

The Huffman coding is a technique that is a greedy algorithm used for lossless data compression. This Huffman encoding algorithm encodes the given data to bit stream. The bit stream is a collection of bit values where the encoded transform coefficients of the frame is stored as a single bit stream using which the size is calculated. The character which occurs most frequently gets the smallest code and the character which occurs least frequently gets the largest code.

The output from Huffman's algorithm can be viewed as a variable-length code table for encoding a source symbol. Thus, it could be calculated by constructing a binary tree in which the coefficients are placed in this tree and added weight for both child nodes of the ordered valued of the coefficients. This could be given as:

$$\text{Average code length per character} = \frac{\sum(\,frequency(i) * code\ length(i))}{\sum frequency(i)}$$

$$= \sum(\,probability(i) * code\ length(i))$$

The number of bits in the Huffman encoded coefficients is given by:

Total number of bits in Huffman encoded message

= Total number of characters in the message x Average code length per character

= $\sum$ (frequency x Code length)

From this encoding process we could be able to retrieve the same data as before encoded as the bit stream by traversing the binary tree backwards.

5.2.4 SCALAR DEQUANTIZATION

The dequantization is an inverse of the quantization process in which the values that are reduced in the scalar quantization is somewhat retained and the quality factor is multiplied with those encoded quantized values. In the process there will be some loss in the values, this loss of values will lead to compression of the frame. This process is carried out as:

$$U(x, y) = \operatorname{sgn} V(x, y) * \Delta$$

where V (x, y) represents quantized coefficient, U (x, y) represents output of dequantized coefficient and Δ represents quantizer step size.

5.2.5 INVERSE TRANSFORMATION

The inverse transformation is also carried using the Orthogonal Polynomial Transformation (OPT) in which the dequantized values are transformed back from Frequency domain to spatial domain. Thus, its values are retained back to spatial domain i.e.) normalized using some normalization factor. This is also discussed in Chapter 4.

The inverse transformation process is the inverse process of encoding transformation process. Due to some steps of encoding process like quantization, the output image after decoding is not very the same as the original image. But the degree of loss be controlled by the quantization factor so that the error is reduced.

Thus, the output obtained from this decoding process provides the compressed frame with some loss of pixel values depending on the respective quantization applied to them. The Block-Based Transformation of these process corresponds to the formation of blocky noise along the end of every tile. The removal of this blocky noise is discussed in the next chapter.

CHAPTER – 6

PHASE II: DESIGN OF DEBLOCKING FILTER

The proposed method for designing a deblocking filter aims at removing the block artifact occurring in the video frames by an adaptive filtering technique. In this section, the steps involved in the design of the proposed design for deblocking filter is described. These are the following steps involved in it:

1. Transform Coding
2. Low level feature extraction
3. Model for feature extraction
4. Deblocking through box filter

6.1 TRANSFORM CODING

The reduction of blocky noise is carried out in the features of the encoded frame. Thus, for the process to be done Orthogonal Polynomial Transformation (OPT) is used again to transform the values of spatial domain of the encoded frame to frequency domain, as it is seen that extraction of features can be done in frequency domain with more accuracy.

Thus, the encoded image is transformed into the frequency coefficients and then are evaluated for the reduction of the blocky noise.

6.2 LOW LEVEL FEATURE EXTRACTION

After applying Orthogonal Polynomials Transformation (OPT), we obtain transformed co-efficients of the compressed input image. Now we are extracting the low-level components in the obtained forward OPT values. The obtained forward OPT is of the form (27 x 1) for a single (3 x 3) block of the image.

In OPT the obtained β comprises of three co-ordinates viz. i, j, k. By analyzing these OPT transformed values, if any of the two co-ordinates are zero, then those values indicate the high-level feature of the image i.e., the edge component of the image. By taking the compliments of these value we obtain the texture components of the image. The texture represents the low-level components of the image. Abrupt change of the consecutive transformed value indicates edges and the gradual change of the transformed value indicates the texture primitive. These texture primitives are isolated and proceeded for further processing as explained in the following sections.

6.3 MODEL FOR FEATURE EXTRACTION

The formula indicating the low-level feature is given below:

$$G(u, v) = \beta ijk, \text{ where } i \neq 0, j \text{ and } k=0$$
$$j \neq 0, i \text{ and } k=0$$
$$k \neq 0, i \text{ and } j=0$$

The retrieval of the texture component corresponds to the complement of the G(u,v) , given as:

$$\overline{G(u,v)} = \{ \beta ijk \mid \beta ijk \notin G(u,v) \}$$

where βijk represents the transformed coefficient values.

6.4 DEBLOCKING THROUGH BOX FILTER

Box filtering involves replacing each pixel of an image with the average in a block. It is basically an average-of-surrounding-pixel kind of image filtering. It is actually a convolution filter which is a commonly used mathematical operation for image filtering. A convolution filter provides a method of multiplying two arrays to produce a third one. In box filtering, image sample and the filter kernel are multiplied to get the filtering result. The filter kernel is like a description of how the filtering is going to happen, it actually defines the type of filtering.

A weighted average block blur (also known as a block linear filter) is a spatial domain linear filter in which each pixel in the resulting image has a value equal to the average value of its neighboring pixels in the input image. It is a form of low-pass ("blurring") filter. A 3 by 3 box blur can be written in matrix notation as

$$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}.$$

Initially, the image is divided into 3x3 blocks and then convolution is performed with the blur matrix so that the result of this operation yields a normalized image. This is done for the texture primitives which are extracted from the forward OPT image as explained briefly in previous section.

Thus, the final output of the design of deblocking filter is obtained by combining the deblocked filter of all extracted features together and its analyzed that the blocky noise is reduced and the visual quality of the frame is improved.

Algorithm: Proposed Design for Deblocking Filter.

Input: A frame and its subsequent frames from a standard video.

Output: Deblocked frame.

BEGIN

Step 1: Extract the frames from any standard video.

Step 2: Perform forward transformation using OPT.

Step 3: Apply Scalar Quantization to the transformed coefficients.

Step 4: Apply Entropy coding for the quantized coefficients.

Step 5: Perform Scalar Dequantization to the quantized coefficients.

Step 6: Perform Inverse transformation to the dequantized coefficients to obtain the encoded frame.

Step 7: Extract features using forward transformation.

Step 8: Apply Box Filter to reduce Blocky noise.

Step 9: Reconstruct the frame by combining the processed components.

Step 10: Repeat Step 2 to Step 9 till last frame is reached from video.

END

Thus, the main of this deblocking filter is to reduce the blocky noise of the compressed frame and to enhance the visual quality of the image.

6.5 PERFORMANCE MEASURE

To evaluate the effectiveness of the proposed orthogonal Polynomials Transformation based deblocking scheme, standard measure viz. Mean Square Error (MSE), is used. The Mathematical formula for computation of MSE is:

$$MSE = \frac{1}{m\ x\ n}\sum_{i=1}^{m}\sum_{j=1}^{n}[\,I\,(i,j) - I'(i,j)]^2$$

where I (i, j) and I'(i, j) represent the intensity of the actual frame and resultant frame pixel positions at (i, j), and m, n and are the height and width of the frame.

CHAPTER-7

EXPERIMENT AND RESULTS

The design of de-blocking filter comprises a lot of step which are briefly explained in chapter – 5. The results obtained for a sample input frame of a standard benchmark video for each step is presented in this chapter. Each frame of size (256 x 256) with the pixel values in the range 0 – 255 in each of the RGB color space could be subjected for the required procedure to reduce the blocky noise of the encoded frame.

The input frame extracted from the standard video, given in Figure 7.1(a), is subjected to the video coding in which the frames get reduced in size and pixel values get compressed. The compressed frame is represented as the encoded image in Figure 7.1 (b). The encoded frame is now subjected for the feature extraction which is carried out using OPT and the features get extracted as shown in Figure 7.2, which describes the texture component of the image.

Fig. 7.1 (a) Original frame extracted the standard video

Fig. 7.1 (b) Encoded input frame for the proposed system

Fig. 7.2 Textural feature extracted from the input frame

Thus, the final resultant output of the reduced blocky noise using the input frame with our proposed system is shown in the Figure 7.3.

Fig. 7.1 (b) Input frame with visible Blocky noise

Fig. 7.3 Final output of the proposed Deblocking filter

In this the Box filter is applied to the encoded frame thereby reducing the block artifact. Thus, the encoded image and the resultant reduced block artifact image is compared.

There are many other techniques used to reduce the block artifacts in an image and their performance measure is measured in terms of their Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) the lesser the value of the MSE the greater the frame and vice versa for those in case of PSNR.

Table 7.4 Results of various quantized frames in which the deblocking filter method is used to reduce the Block Artifact of the compressed frame.

Input frame of Quantization	MSE	PSNR
10	3.78	23.72
20	2.23	25.17

This table shows the performance measure of various frames under different quantization, so its seen that both MSE and PSNR changes relatively under different quantization applied. Thus, this chapter explains the proposed technique for reducing the deblocking filter and provides the desired output.

CHAPTER-8

CONCLUSION

8.1 GENERAL DISCUSSION

People now a days ran out of storage often. Multimedia data forms a huge part in data world. Our proposed method reduces the storage of multimedia data (Video) without any sort of reduction in the quality of it. Videos are compressed in many ways. But there will be blocking artifacts occurring on the image. Our proposed methodology implies a novel approach to reduce this blocking artifact. This retains the quality of the image frame even after compression. In this internet world, peoples were adapted to high speed environment. Thus, for high speed data transfer, a low storage data will be more convenient. But we people do feel uncomfortable in quality loss while compressing data. Our methodology implements a new de-blocking filter which reduces the blocking artifacts and retains the quality of the data. We implemented Orthogonal Polynomial Transformation to convert the input frame into transformed domain. The edges and smooth regions are separated and the de-blocking filter is applied which were formed during the compression process. As a result of our methodology we obtain a video which is highly compressed and the quality of the video remains unchanged.

8.2 SUMMARY

The contributions made in the project are summarized as:

- Extraction of features is carried out in frequency domain where it may be accurate and efficient.

- Although many techniques of reducing blocky noises have been used Box filter is a standard way to reduce the block artifact.
- The reduced blocky noise image may not have a good visual quality but a further more techniques of image restoration or enhancement may lead to some precise improvement of visual quality.

8.3 FUTURE WORKS

The method of designing a deblocking filter in video coding is carried out in terms of individual frames, whereas since it's up to a video coding a Motion estimated and compensated frame may reduce complexity when it comes for a video coding. Thus, also introducing some image enhancement techniques in this filter designing will results in a good visual quality and provides a perfect video codec.

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