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Performance Analysis of K-Multiple Paths using Optimized Value of Quantization Parameter

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Abstract- Bandwidth requirement for video transmission is a dynamic parameter and changes with the requirement of user. Quantization method plays a key role for rate distortion optimization in video compression algorithm. In this paper a proposed optimization based algorithm is develop with the integration of A*prune algorithm. This algorithm improve the quality and compression ratio of the reconstructed frame, an optimized value of the quantization parameter is find out with the help of firefly optimization algorithm.
Results are validated with slow motion video sequences, Mother-daughter having motion activity and varying frame rate 5 fps. In case of slow motion Mother-daughter video frame at frame rate 5 fps total bit budget reduced 5615–3186 bits and complexity reduced 102.57–99.23 s with acceptable degradation in PSNR 30.14 dB to 29.25 when we compare fix quantization method with the variable quantization method. At same frame rate 5 fps using proposed algorithm bit budget 1631 bits and complexity 61.06 s with PSNR 30.52 dB, it is found that there is improvement in parameters as compare to fix and variable quantization method, it is found that there is improvement in parameters as compare to fix and variable quantization method. From the above comparison it is concluded that using proposed algorithm complexity and bit budget is reduced and improvement in PSNR is achieved as compare to variable quantization parameter.

Keywords: Video transmission, Quantization, Rate distortion

I. INTRODUCTION

The video data processing is a major challenge in the communication field. The data can be defined as the set of information and redundancy. The information is the segment of data which always preserve in the original form and reflects the meaning of data. The redundancy is that segment of data which can be removed while not required and reinserted at the requirement [1]. The redundancy is reinserted to reconstruct the data in its actual form. So the reduction in the redundancy of data and minimize storage space necessity is called data compression [2].
From this, it is concluded that compression, is the process of reduced the data and maintain the quality without loss in information. Out of data communication video compression is a major challenging task in multimedia communication. High coding efficiency, complexity reduction, and error resilience are three major challenges exist in mobile video compression. To consider the above challenges different types of video compression coder was developed according to the requirement of various application area [3].
As a result, the above-mentioned issue can be minimized through the help of proposed work in this paper dealing with our research. Accordingly, this can only be possible with the modification in the technique used in the quantization. Similarly, it can also be through the use of the proposed algorithm to ensure the reduction of the computation work by saving huge bit budget bits while maintaining the quality of the reconstructed video. It should be noted that this modification work is possible when a large value of the quantization parameter is used for large block size and small value is used for the small size of blocks. Particularly, this is because the small blocks come from the informative portion of the frame while the large sizes of the block come from the non-informative portion of the frame. Therefore, by using this strategy, the efficient allocation of bits between motion vectors and residual coefficients is done and this further reduces the total number of bits with acceptable degradation in PSNR [4]. In order to improve PSNR and bit budget an optimized quantization parameter with variance based quad tree method is used in proposed work.

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II. Related work

The human eye is considered to be less sensitive to the high-frequency coefficients as compared to low-frequency coefficients. Therefore, for the compression purposes, the removal of high-frequency coefficients having no noticeable degradation in the quality of the image is observed. There are several techniques adopted in video compression technique to reduce this high-frequency component for better visualization of video content. Out of Notably, quantization comprise of scalar quantization, which deals with a single variable that is random and has low computational complexity, and the vector quantization, which deals with the vector of variable that are random and usually have high computational complexity that is rapidly increasing with the increase in the dimension order[5]. The scalar quantization methods are involved in the most video and image coding standards with the blend of the transform coding.

Vector quantization (VQ) method is used for the two-dimensional signal. Firstly two-dimension signal is divided into blocks of the same size or the variable size [6] [7]. VQ compressed the residual signal that is the difference of the current signal and signal comes after motion estimation and compensation**.** At the encoder side, each block is compressed with each member of the lookup table by finding the closest match in term of distortion measure. This closest match of the block in the lookup table is the transmitted in compressed coefficient representation. Same lookup table members are used for reconstruction of block coefficient and based on this current block is determined. The distortion introduced by the quantization process is the key parameter of the performance evaluation of the vector quantization process [8].

It is observed that if the quantized value of the video sequence is the same as the input video sequence when distortion is zero. Quantization parameter plays a key role in cases of rate-distortion optimization since it controls the distortion within the given budget for the bits.

Next target is to achieve an ideal value of rate and distortion by the use of the lagrangian optimization [9]. Thus, this method offers a tradeoff between rate and distortion and aims at finding out the most suitable path in terms of the value of rate and distortion optimized. For further continuation of this research, the key target is saving the bandwidth of the network and provides the quality of service to the user [10]. To achieve the optimal value of rate-distortion it is studied from the literature that suitability of MCSP algorithm with the video compression algorithm. In MCSP algorithm RD optimization is done on the basis of shortest path algorithm and generation of a number of paths from the source to the destination [11] [12]. In order to further improvement in the RD optimization and reduce the complexity of the algorithm a multi-constraint, A* pruning algorithm is used to sort out the most feasible paths from the pre-computed paths those satisfied the condition of multi-constraint parameter [13][14]. In this case, the rate and distortion are the constraints and the paths selected are believed to satisfy both the rate and distortion conditions with the stipulated bit budget**.**

III. Methodology

In this work, the quadtree has been generated on the basis of skipping some depth levels. The skipping of depth depends upon the correlation and variance between the blocks of the current frame and previously reconstructed frame. By doing so there is approximately 50%of time saving is achieved. It is also found that partitioning of the frame depends upon the complexity, and this complexity is statistically represented by the variance of the block. Variance of a block based on the correlation between the pixels. The region of the frame having high correlation between the pixels is represented by the smooth region and less correlation between the pixels represented by the activity region. In this strategy, the low variance region is represented by the large block size and high variance region represented by the small size of blocks. With the adopting of this variance based quadtree structure method, rate-distortion optimization process is decreased for a frame with high value of the variance. In this method depth level of quadtree is controlled by finding out the appropriate value of the threshold V_{th} for each depth level of the quadtree structure. This threshold value is generated on the basis of the variance-based probability density function. In this quadtree partitioning strategy blocks having same depth levels, are merged and those blocks having different depth level not merged. From this method it is found that complexity of the quadtree formation is reduced by predicting the depth level instead of running rate-distortion optimization (RDO) process. In the current quadtree structure population of the blocks are divided into two categories i.e merged and non-merged population on the basis of variance. It is found that blocks belong to non-merged population category encoded with the full rate distortion optimization process up to the current depth level. On the other side blocks come under the merged category encoded with less depth level as compare to the non-merged category [15].

l_{nm} = Depth level of non-merged blocks

l_m = Depth level of merged blocks

N_c =Variance of the current block

N_{ref} = Variance of the reference block

Block population of the quadtree is categories on the basis of the following relation

The difference between both the current block and reference block ($N_c - N_{ref}$) is compared with the threshold value V_{th}.

If $N_c - N_{ref} > V_{th}$ the condition is satisfied than blocks belong to the merged category otherwise block falls under the non-merged category. In this quadtree decomposition method, the threshold value has linear relationship with the mean 'μ' and standard deviation 'σ' value. From the above observation threshold value can be represented as Eq. 1.

$$[V_{th}]_{l,p} = a.\mu + b.\sigma + c \tag{1}$$

Where a, b, c are the coefficients and *l, p* is the depth level and probability. From the above observation, it is found that two categories of blocks i.e large size and small size are generated on the basis of threshold value. This method reduced the RDO process and simultaneously decreases the complexity of the quadtree. In this quadtree formation strategy $l_m < l_{nm}$ condition is always satisfied. From the overall observation, it is concluded that predicting the depth level of blocks' complexity of the quadtree decreases and saving the large amount of bit-budget.

From the above quadtree generation method, it is found that the large-sized blocks denote the portion that is less informative while the small-sized blocks signify the high informative portion of the video frame. As this research continues, the high value of the quantization parameter is used for the blocks of large size while the quantization parameter of low value is used for the small-sized blocks. Consequently, by using proposed optimized quantization technique is used to find out the appropriate value of quantization parameters for informative and non-informative blocks and achieve good quality of performance parameters.

With the previous reviews, it was found that uniform quantization method reduced the total number bit budget. In this method it is also found that with the decrease in total bit budget distortion bit budget is increased [15]. In this method quality of the output video sequence is decreased and measured in terms of PSNR [16][17].

Equation number 2 is used to find out the rate by taking the same quantization parameter for each particular type of blocks.

$$r_1 = 2^{(QP-4)/6}\left[\frac{K_{16\times16}}{MSE_{16\times16}\sqrt{\pi}} + \frac{K_{8\times8}}{MSE_{8\times8}\sqrt{\pi}} + \frac{K_{4\times4}}{MSE_{4\times4}\sqrt{\pi}}\right] \tag{2}$$

From the analysis of Eq. 2, it is observed that compression of each type of block with the same quantization parameter. Therefore, with this methodology, the large saving of bit budget is achieved but R-D optimization achieved is not as appropriate as required because the blocks having more information are equally suppressed as fewer information blocks.

Therefore, to solve the defined issue of traditional work, this study develops a novel approach that utilizes the information-dependent variable quantization method which improves the bit budget with resolutions of the output video sequences. In this approach, the parameters of quantization are defined as per the block size of the frame. The variable value of quantization parameters is defined in this work and improves the quality and bit budget qualitatively.

In further continuation of this work, it is observed that to find out the appropriate quantization parameter for different video sequence is a time-consuming task. In this context the complexity of the algorithm is increased, due to this, it is less effective for mobile and real-time video communication application. In order to overcome this problem of complexity, an optimization algorithm is used to find out the optimized value of the quantization parameter. This optimized algorithm provides the best result in terms of complexity and quality for a different class of video sequence as compared to the previously adopted information based quantization method.

It is observed that optimization algorithm is best suited for the finding out the appropriate quantization parameter in the video compression algorithm. There is a different class of video exists for various video transmission application. A different class of video sequence having a different bit of budget and information level. It is found that in case of uniform quantization parameter a separate quantization parameter is calculated for each type of video sequence. It is found that to calculate the optimal quantization parameter every time is a complex task. On the other side if we use the variable quantization method than to select the optimal quantization parameter for each size of block for a different class of video sequence is a complex task and not found optimal outcomes.

To avoid this complexity in information-based variable quantization method optimized value of the quantization parameter is used in the video compression algorithm. To find out the optimized value of quantization an optimized algorithm is used. The optimized algorithm provides the most optimal value quantization parameter for each type of block size in self-healing environment. This optimization algorithm is the most appropriate choice for each class of video sequence. To find out optimum value of quantization parameter each type of block, an upper bound and lower bound limit is set and number of iteration is fixed for most appropriate value. This most appropriate value of quantization declared on the basis of objective function.

Firefly algorithm frequently used for optimization purpose in engineering problem. With some modification and hybridization in the firefly algorithm, it is used for solving the nonlinear problem.

In our proposed work optimization is performed using the most effective firefly algorithm. The experimental result is verified using a benchmark video sequence and PSNR and the total bit budget is investigated. Comparative analysis based on performance parameter is done with the simple information based quantization parameter. From the obtained results it is found that the optimized quantization method is far better in terms of quality and storage capacity.

II. RESULTS

In this case, we observe the results for the slow-motion mother-daughter video sequence at 5 fps frame rate. Table 1 shows the performance parameter derived using fix quantization method and variable quantization method at a frame rate of 5 fps. The comparison between the performance parameter derived using the fix quantization and information based variable quantization method has been done at search regions ± 8. It is observed that variable quantization method technique was able to reduce the overall bit budget and some acceptable degradation in PSNR as compare to the fix quantization method. Table 2 shows the performance parameter derived using optimized variable quantization method at a frame rate of 5 fps and search regions ± 8. It is found that performance parameter derived using the optimized information based variable quantization method reduce the bit-budget and improve the quality in terms of PSNR.

Figure 1, shows the original quadtree structure of the slow motion Mother-Daughter video frame Figure 2, shows the quadtree structure of the slow motion Mother-Daughter video frame for the fix quantization method and structure that using fix quantization parameter each blocks having active and inactive region is quantized by the same quantization factor. Similarly from Figure 3 and4 shows a quadtree structure for variable quantization parameter and optimized information based quantization method. It is concluded that variance based quadtree structure compressed by optimized quantization parameter and provided the efficient bit budget and improved value of PSNR.

Table 1: K-Multi-constraint Shortest Paths of Mother-Daughter Video Sequence using Fix QP and IV-QM with *window size* = ± 8, (*R* = 1500, *D* = 5000, *FR* = 5 fps)

P	R_{FQP}	$R_{IV\text{-}QM}$	D_{FQP}	$D_{IV\text{-}QM}$	TB_{FQP}	$TB_{IV\text{-}QM}$	T_{FQP}	$T_{IV\text{-}QM}$	$PSNR_{FQP}$	$PSNR_{IV\text{-}QM}$
1	988	518	4619	2656	5607	3174	89.06	88.66	30.12	29.20
2	1054	536	4553	2641	5607	3177	101.44	97.55	30.13	29.20
3	1114	548	4503	2635	5617	3183	105.26	100.39	30.13	29.25

4	1123	554	4496	2633	5619	3187	108.25	103.48	30.15	29.30
5	1141	578	4486	2629	5627	3207	108.56	106.11	30.17	29.30
Avg.	1084	547	4531	2639	5615	3186	102.5	99.23	30.14	29.25

Table 2: K-Multi-constraint Shortest Paths of Mother-Daughter Video Sequence using Fix QP and optimized value of IV-QM with *window size* = ± 8, (*R* = 1500, *D* = 5000, *FR* = 5 fps)

P	R_{FQP}	$R_{OIV\text{-}QM}$	D_{FQP}	$D_{OIV\text{-}QM}$	TB_{FQP}	$TB_{OIV\text{-}QM}$	T_{FQP}	$T_{OIV\text{-}QM}$	$PSNR_{FQP}$	$PSNR_{OIV\text{-}QM}$
1	1038	530	4902	1093	5940	1623	64.21	56.84	30.12	30.50
2	1104	536	4836	1087	5940	1623	65.50	59.00	30.13	30.50
3	1170	548	4781	1077	5951	1625	66.61	60.90	30.13	30.50
4	1260	569	4721	1063	5981	1632	67.62	63.46	30.15	30.55
5	1380	611	4661	1042	6041	1653	68.71	65.14	30.17	30.55
Avg.	1190	558	4780	1072	5971	1631	66.54	61.06	30.14	30.52

Original Frame **Quad Tree Decomposition**

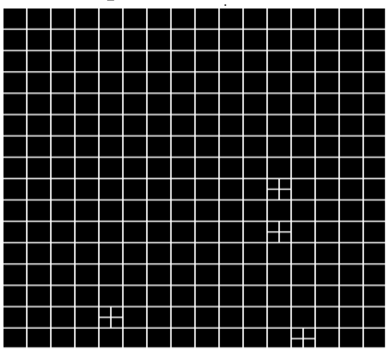

Fig 1: Original Frame of Shortest Path Mother-Daughter Video Sequence with Frame Rate 5 fps with Search Window =±8

Reconstructed Frame **Quad Tree Decomposition**

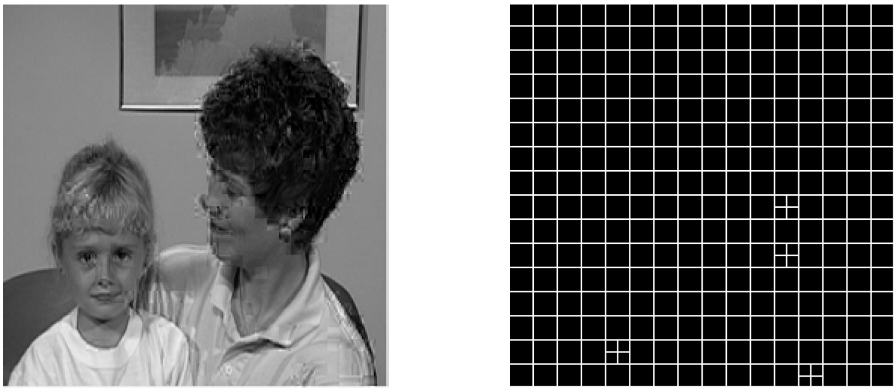

Fig 2: Reconstructed Frame of Shortest Path Mother-Daughter Video Sequence with Frame Rate 5 fps, at Fix Quantization Parameter and Search Window =±8

Reconstructed Frame **Quad Tree Decomposition**

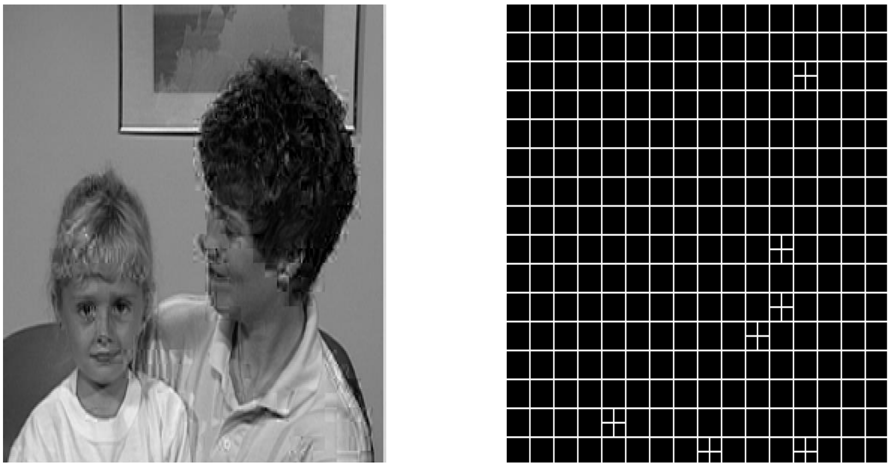

Fig 3: Reconstructed Frame of Shortest Path of Mother-Daughter Video Sequence with Frame Rate 5 fps, (Quantization Parameter = 24 for Block Size 16, 16 for Block Size 8, 8 For Block Size 4) and Search Window = ± 8

Reconstructed Frame **Quad Tree Decomposition**

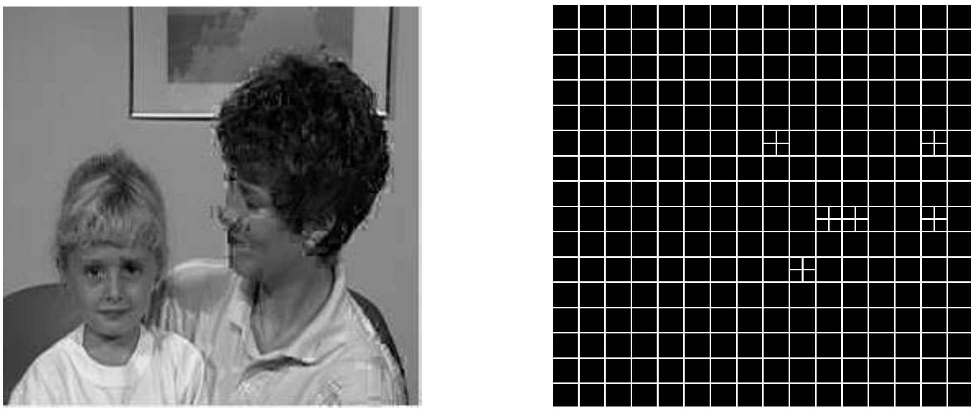

Figure 4: Original and Reconstructed Frame of Shortest Path of Mother-Daughter Video Sequence with Frame Rate 5 fps, using Firefly Algorithm with Search Window = ± 8

III. CONCLUSION

Results shows the comparative analysis between the different quantization method at frame rate such as 5 fps for Mother-Daughter video sequence in terms of bit budget, complexity and PSNR. It is concluded that with the optimized value of the quantization parameter PSNR value is better as compare to variable and fix quantization method. On the other side if we compare the different quantization parameter technique in terms of total bit budget saving and complexity, optimized quantization parameter strategy gives the outperforming results.

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