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Heterogeneous Image Transcoding using Inter-conversion Matrices

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Abstract: We propose a new scheme for heterogeneous transcoding of image files from JPEG to JPEG 2000 format with directional filter analysis and modified SPIHT coding scheme. The optimal parameters $QF^*_{out}(I,D)$ and $Z^*(I,D)$ that produce high perceived quality in terms of SSIM are selected using a prediction algorithm. Furthermore, the heterogeneous image transcoding are performed using inter-conversion matrices which reduce the computational overheads. The resultant coefficients, using BDCT to DWT, are analyzed by Directional Filter banks (DFBs). The DWT-DFB coefficients are encoded via progressive SPIHT algorithm to meet the devices constraints. In the experimental set up, the quality of reconstructed image is measured using PSNR and SSIM. It is shown that there is an improvement of more than 4 dB in the quality of reconstruction for the same bit rate as that of mere DWT-based SPIHT encoding.

Keywords: Image transcoding, Inter-conversion matrix BDCT to DWT, SPIHT Algorithm.

1 Introduction

Transcoding has become inevitable in cases where a target device has limited storage capacity that mandates a reduced file size or to convert incompatible data to a better-supported or modern format as illustrated in Fig. 1 Reducing the file size of a JPEG image to meet bandwidth or terminal constraints is a common transcoding operation. To enable the delivery of multimedia content to devices with limited capabilities, high-volume transcoding servers must rely on efficient adaptation algorithms. A video coding scheme that uses hybrid Discrete Cosine Transform (DCT) and motion compensation along with scalable coding techniques for transcoding has been successfully employed [1]. Along with a scalable coding strategy in the context of video transcoding, a DCT-to DWT-based image transcoder to convert the pre-existent image data was proposed using matrices [2]. It was possible to demonstrate transcoding for deblocking of the DCT-coded images in wavelet domain.

A technique for transcoding the DCT blocks to wavelet coefficients was established directly in the transform domain. Filtering, IDCT and down sampling operations in a single combined step were performed [3]. A technique for transcoding of DWT coefficients to Block DCT coefficients was proposed in the transformed domain itself. The technique includes transformation of DWT coefficients into up sampled DCT blocks combined with filtering. The proposed algorithm is useful in cases where inputs are of DWT coefficients and the DCT-based applications [4]. An algorithm for predicting the optimal combination of QF and scaling parameters for various device constraints under different viewing conditions was proposed [5]. It was aimed to identify the best combination of QF and scaling parameters to produce the best quality of reconstruction in terms of SSIM. A quality-aware transcoding system [6] which considers the quality of transcoded images when QF and scaling are selected jointly with a goal to maximize the user experience under a given viewing condition. To adapt JPEG images to devices with varying capabilities, an algorithm for predicting the file size with respect to the changes in QF and resolution was proposed [7]. The QF scaling-based prediction algorithm was used to predict the file size of the original image and scaling factor. The resolution of the original input image was also considered for improving the accuracy of prediction.

Due to de-correlation and energy compaction properties, DCT and DWT are popular for compression related works. DCT coding has been adopted in

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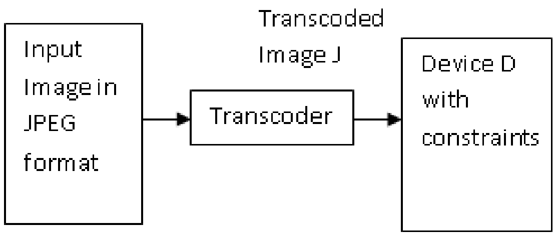

Fig. 1: Illustration of image transcoding technique

image/video compression whereas DWT is used in JPEG 2000 standard. Wavelet-based coding outperforms other types in terms of coding efficiency and reconstruction quality [8]. Heterogeneous image transcoding performs different transformations between compressed images. Transcoding avoids inverse transform and retransform operations and saves computation. A stream-based control for videos for transcoding along with a queue waiting strategy was proposed [9]. The admission controller logic could make the decisions whether to admit an incoming video stream or reject. At the same time, to reduce the jitters arise due to transcoders, a job scheduling mechanism was also presented.

In [10], a video transcoding system for various video codec formats using Hadoop-based distributed cloud file management system was introduced. This system was designed to provide various types of video content to different devices such as mobile phones, personal computers and television The video on-demand transcoders for streaming the incoming video files to match the characteristics of the end user devices using cloud computing techniques was proposed [11]. In order to maintain the QoS for viewers and efficient streaming solutions, Cloud-based Video Streaming Services architecture was also introduced. The paper is organized as follows. In Section 2, matrix representation of BDCT and DWT are described. Also it describes about the proposed inter-conversion matrix representation. In Section 3, the experimental set up for the proposed heterogeneous image transcoding system using inter-conversion matrix is described. Section 4 shows the implementation and simulation results. Section 5 concludes the paper.

2 Matrix Representation of BDCT and DWT

2.1 Matrix Representation of BDCT

Let us assume that a block of an image is represented by 8×8 pixels is denoted by $I_{8\times8}$. Let $DCT_{8\times8}$ be its corresponding DCT coefficients. $D_{8\times8}$ represents the 8point 1D DCT matrix. The matrix form of forward and inverse DCTs are as follows.

$$DCT_{8\times8} = D_{8\times8} I_{8\times8} D^T_{8\times8} \tag{1}$$

$$I_{8\times8} = D^T_{8\times8} DCT_{8\times8} D_{8\times8} \tag{2}$$

The input image of size 16×24 is taken for simplicity and it is represented as

$$I_{16\times24} = \begin{bmatrix} I_{8\times8}(1) & I_{8\times8}(2) & I_{8\times8}(3) \\ I_{8\times8}(4) & I_{8\times8}(5) & I_{8\times8}(6) \end{bmatrix} \tag{3}$$

The corresponding DCT matrix is represented as

$$DCT_{16\times24} = \begin{bmatrix} DCT_{8\times8}(1) & DCT_{8\times8}(2) & DCT_{8\times8}(3) \\ DCT_{8\times8}(4) & DCT_{8\times8}(6) & DCT_{8\times8}(6) \end{bmatrix} \tag{4}$$

$$DCT_{16\times24} = \begin{bmatrix} D_{8\times8}I_{8\times8}(1)D^T_{8\times8} & D_{8\times8}I_{8\times8}(2)D^T_{8\times8} \\ & D_{8\times8}I_{8\times8}(3)D^T_{8\times8} \\ D_{8\times8}I_{8\times8}(4)D^T_{8\times8} & D_{8\times8}I_{8\times8}(5)D^T_{8\times8} \\ & D_{8\times8}I_{8\times8}(6)D^T_{8\times8} \end{bmatrix} \tag{5}$$

The DCT generation matrix is defined as given in the following equation.

$$G_{16\times16} = \begin{bmatrix} D_{8\times8} & O_{8\times8} \\ O_{8\times8} & D_{8\times8} \end{bmatrix} \tag{6}$$

where $O_{8\times8}$ represents the 8×8 zero matrix. The DCT coefficients of size 16×24 in Eq. (4) can be further simplified as

$$DCT_{16\times24} = \begin{bmatrix} D_{8\times8}O_{8\times8} \\ O_{8\times8}D_{8\times8} \end{bmatrix} \begin{bmatrix} I_{8\times8}(1) & I_{8\times8}(2) & I_{8\times8}(3) \\ I_{8\times8}(4) & I_{8\times8}(5) & I_{8\times8}(6) \end{bmatrix} \times \begin{bmatrix} D^T_{8\times8}O_{8\times8}O_{8\times8} \\ O_{8\times8}D^T_{8\times8}O_{8\times8} \\ O_{8\times8}O_{8\times8}D^T_{8\times8} \end{bmatrix} \tag{7}$$

The 8×8 BDCT of an $N\times M$ image, where N and M are multiples of 8 using the Eq. (7) can be represented as

$$DCT_{N\times M} = G_{N\times N} I_{N\times M} G^T_{M\times M} \tag{8}$$

Similarly, the IDCT can also be derived and given by

$$I_{N\times M} = G^T_{N\times N} DCT_{N\times M} G_{M\times M} \tag{9}$$

2.2 Matrix Representation of DWT

The matrix form of both forward and inverse DWTs can be shown using Daubechies coefficients. The simplest form of wavelet transformation matrix is called DAUB4 which has only four coefficients and are given by

$$c_0 = \frac{1+\sqrt{3}}{4\sqrt{2}},\ c_1 = \frac{3+\sqrt{3}}{4\sqrt{2}},\ c_2 = \frac{3-\sqrt{3}}{4\sqrt{2}},\ c_3 = \frac{1-\sqrt{3}}{4\sqrt{2}} \tag{10}$$

The forward and inverse DWT of $N\times M$ image, where N and M are multiples of 8 are given by

$$DWT_{N\times M} = X_{N\times N} I_{N\times M} X^T_{M\times M} \tag{11}$$

$$I_{N\times M} = Y_{N\times N} DWT_{N\times M} Y^T_{M\times M} \tag{12}$$

2.3 Inter-conversion Matrix Representation

The matrix representation of BDCT-to-DWT using inter-conversion matrices can be expressed as

$$DWT_{N\times M} = X_N G_{N\times N}^T DCT_{N\times M} G_{M\times M} X_M^T \quad (13)$$

where $T_{N\times N} = X_N G_{N\times N}^T$ and $T_{M\times M}^T = G_{M\times M} X_M^T$ are the transcoding matrices which are used as inter-conversion matrices to convert BDCT to DWT. The transcoding matrices are computed by the column-wise DWT of $G_{N\times N}^T$ and the row-wise DWT of $G_{M\times M}$ respectively. The matrix representation of DWT-to-BDCT using inter-conversion matrices can be expressed as

$$DCT_{N\times M} = G_{N\times N} Y_N DWT_{N\times M} Y_M^T G_{M\times M}^T \quad (14)$$

where $T1_{N\times N} = G_{N\times N} Y_N$ and $T1_{M\times M}^T = Y_M^T G_{M\times M}^T$ are the inverse transcoding matrices to convert DWT to BDCT. T and $T1$ are the transcoding matrices used in the proposed system to reduce the computational complexity of the transcoder.

3 Experimental Setup for the Proposed Heterogeneous Image Transcoding using Inter-conversion Matrices

Let I be a JPEG compressed image and the Quality factor QF, file size, width, height of the compressed input JPEG image be $QF(I)$, $S(I)$, $H(I)$, $W(I)$ respectively. Most of these information are readily available in the file header. The restrictions in the specifications of a receiving device D may be denoted as follows: $S(D)$, $H(D)$, $W(D)$ be the maximum file size that could be handled by the receiver, the height and width of the image. QF can take values in the range of $1 \leq QF \leq 100$, from coarsely quantized to lossless representation. The acceptable image format of the receiving device is JPEG 2000. Let Z be the aspect-ratio-preserving scaling parameter. Z can be between 0 and 0.1. The image transcoding system specification $T(I, QF_{out}, Z)$ applies the QF_{out} and Z on I to return the compressed image such that it can satisfy constraints given in Eq. (11).

$$\begin{aligned} T(I, QF_{out}, Z, D) &= QF_{out}^*(I, D), \\ Z^*(I, D) | T(I, QF_{out}, Z) &= T_F(I, QF_{out}, Z, D) \end{aligned} \quad (15)$$

Among the possible values of QF_{out} and Z, the selection of $QF_{out}^*(I,D)$, $Z^*(I,D)$ is carried out such that it will maximize the quality of reconstructed images. The main objective of the work is to select the optimum values of QF and Z which perform a feasible JPEG image transcoding operation by reducing the bit rate to meet the viewing condition and bandwidth available, at the same time the perceived quality of the image to be maintained.

The proposed algorithm predicts the compressed file size of the transcoded image J. The predictor is modeled as given below.

$$\hat{S}(I, QF_{out}, Z) = S(I)\hat{s}(QF(I), QF_{out}, Z) \quad (16)$$

where $\hat{S}(I, QF_{out}, Z)$ is the predictor for a given JPEG image I, QF_{out} and Z. $\hat{s}(QF(I), QF_{out}, Z)$ is a relative size predictor given by

$$\hat{s}(QF(I), QF_{out}, Z) = \frac{1}{|T_{QF}|} \sum_{J \in T_{QF(I)}} s(J, QF_{out}, z) \quad (17)$$

where $s(J, QF_{out}, z)$ is computed using the Eq. (18)

$$s(J, QF_{out}, z) = \frac{S\left(T(J, QF_{out}, z)\right)}{S(J)} \quad (18)$$

where $T_{QF(I)} \subseteq T$ is the subset of images in the training set T of the same QF as I and $\left|T_{QF(I)}\right|$ is its cardinality. The proposed work is used to determine the appropriate values of QF and scaling parameters $(QF_{out}^*(D)$ & $Z^*(D))$ which meet the target device's capabilities such as bit rate, file size and perceived quality of reconstruction. The device constraints are also given as another input to the transcoder. Inter-conversion matrix is used in the proposed work to convert BDCT to DWT which satisfies the device image format. Inter-conversion matrix avoids inverse transform and re-transform operations and saves computations in the proposed work. The resultant coefficients are rearranged in the form of conventional DWT subband structure. Directional Filter Bank (DFB) analysis [12] using fan filters is also applied in the second stage which provides the angular decomposition. Angular analysis of subbands using DFB is applied with the same number of directions to each subband at a particular level. In the finest scale, maximum amount of directions-based DFB is applied. Direction specifications for the consecutive level are reduced by half in order to satisfy anisotropy scaling [13]. Even though it is mentioned in the literature that LH and HL subbands have the vertical and horizontal details, wavelet filters do not split the frequency space exactly. So, the directions preferred for the angular subband analysis completely cover all the directions.

The resultant subband coefficients are encoded using SPIHT algorithm. SPIHT (Set Partitioning in Hierarchial Trees) is the wavelet-based image compression algorithm which is used in the proposed system in order to convert the image format (JPEG to JPEG 2000) as shown in Fig. 2. One of the main properties of SPIHT encoding is that it can meet the exact bit rate or distortion. This property of SPIHT is required for transcoding to recompress the image according to the diverse capabilities of end user devices.

There are three stages such as initialization, sorting pass, and refinement pass involved in the SPIHT algorithm. The image is encoded using three lists such as LIP (List of Insignificant Pixels), LIS (List of

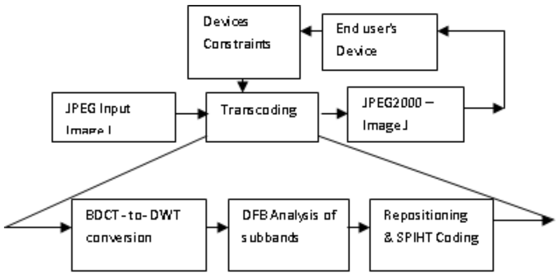

Fig. 2: Illustration of proposed heterogeneous transcoding combined with DWT and DFB based image compression scheme

Insignificant Sets) and LSP (List of Significant Pixels). The algorithm checks the significance of elements in the LIP and then in the LIS during the sorting pass. In the refinement pass, refinement bits are generated for those coefficients which are found to be significant during previous passes. After refinement pass, the threshold is divided by 2 and the nodes in the lists are processed in the same way as above for the new threshold. The sorting and refinements stages are continued until the target bit rate is achieved. The progressive encoding with SPIHT is useful in realizing the bit stream from a wavelet subband structure. The same could also be reconstructed with the required amount of quality of reconstruction. Scalabity is one of the advantages of SPIHT encoding scheme.

4 Results and Discussion

For the original input JPEG image I, the relative file size $s(I, QF_{out}, Z)$ is calculated for the varying quality factor (QF_{out}) and scaling parameter (Z) which is shown in Table 1. The relative file size $s(I, QF_{out}, Z)$ is the ratio between the file size of transcoded image J and original JPEG image I.

Using the prediction algorithm described earlier, the file size is predicted for various values of quality factor QFout and scaling parameter Z which is shown in Table 2. In the near optimal quality JPEG transcoding system, optimal quality factor $Q\hat{F}*_{out}$ is tabulated in Table 3 for various maximum relative file sizes $s_{\max}(I,D)$ and viewing condition $z_V(I,D)$.

In the near optimal quality JPEG transcoding system, optimal scaling parameter $z_V(I,D)$ is tabulated in Table 4 for various maximum relative file size $s_{\max}(I,D)$ and viewing condition $z_V(I,D)$.

Let us consider an end-user device has the following restriction for the image to be displayed such as Maximum permissible file size of the JPEG image is, $S(D) = 26700$ bytes, width of the image, $W(D)$ is 640 pixels, and the height of the image, $H(D)$ is 480 pixels.

Also assume that the input jpeg image I has the following parameters such as the compressed file size, $S(I)$ is 37882 bytes, width, $W(I)$ is 512 pixels, height, $H(I)$ is 512 pixels, and $QF(I) = 80$. The maximum relative file size $s_{\max}(I,D)$ and viewing condition $z_V(I,D)$ are computed as per the equations listed below.

$$s_{\max}(I,D) = \min\left(\frac{S(D)}{S(I)}, 1\right)$$

$$s_{\max}(I,D) = \min\left(\frac{26700}{37882}, 1\right) \approx 0.7$$

$$z_V(I,D) = \min\left(\frac{W(D)}{W(I)}, \frac{H(D)}{H(I)}, 1\right)$$

$$z_V(I,D) = \min\left(\frac{640}{512}, \frac{480}{512}, 1\right) \approx 0.9$$

Using Table 3, $QF_{out} = Q\hat{F}*_{out}(0.7, 0.9) = 76.7 \approx 80$ is chosen. Using Table 4, $Z = \hat{Z}*(0.7, 0.9) = 0.826 \approx 0.8$ is chosen. The input JPEG image is transcoded with the above chosen QF_{out} and Z. After transcoding, the relative file size for the chosen quality factor and scaling parameter $s(I, 80, 0.8) = 0.68$ is obtained from Table 1. The transcoded image meets the target file size, that is $s(I, QF_{out}, Z) \le s_{\max}(I,D), 0.68 < 0.7$. Hence it is taken as optimal quality factor and scaling parameter for a given device and input JPEG image I.

Table 5: Qualitative analysis for various QF_{out}

Quality Factor (QF_{out})	PSNR in dB	SSIM Value
10	30.4095	0.87
20	32.9651	0.92
30	34.2725	0.94
40	35.1271	0.95
50	35.8081	0.96
60	36.4511	0.968
70	37.3254	0.97
80	38.5355	0.978
90	40.8200	0.98
100	58.4716	1.0

Table 5 shows how the quality metrics such as PSNR in dB and SSIM values are varied for the corresponding QF_{out} which varies from 10 to 100 in steps of 10. For low-quality factor, i.e. $QF_{out} = 10$, the table shows the lowest PSNR ($PSNR = 30.4095$). The structural similarity between both the input and output images are different. Hence the SSIM value is 0.87. The gradual increase in the QF_{out} gives the improvement in the quality metrics which is shown in the above Table 5.

For the original input JPEG image I, the relative file size $s(I, CR, Z)$ is calculated for the varying compression ratio (CR) and scaling parameter (Z) which is shown in Table 5. The relative file size $s(I, CR, Z)$ is the ratio between the file size of transcoded image J and original JPEG image I. Table 6 shows how the quality metrics such as MSE, PSNR in dB and SSIM values are varied for the corresponding CR which varies from 10 to 100 in steps of 10. The quality of reconstruction with $PSNR$ in dB for various bit rates in bpp are illustrated with different files which are transcoded using the optimal file size and QF values predicted in image formats in Fig. 3.

Table 1: Relative file size S for varying QF_{out} and $Z \in (0.1-1.0)$

QF/SF	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10	0.014	0.024	0.039	0.056	0.076	0.099	0.124	0.155	0.182	0.213
20	0.017	0.032	0.0558	0.081	0.111	0.147	0.182	0.227	0.269	0.312
30	0.019	0.039	0.0701	0.102	0.140	0.185	0.231	0.288	0.342	0.403
40	0.021	0.045	0.0809	0.119	0.164	0.218	0.272	0.339	0.405	0.483
50	0.023	0.050	0.0911	0.136	0.188	0.248	0.311	0.390	0.467	0.513
60	0.025	0.056	0.1028	0.153	0.212	0.282	0.354	0.445	0.536	0.774
70	0.028	0.065	0.1190	0.179	0.248	0.335	0.425	0.533	0.646	0.910
80	0.033	0.078	0.1463	0.221	0.309	0.421	0.536	0.679	0.821	1
90	0.043	0.109	0.2055	0.318	0.450	0.621	0.796	1.006	1.214	1.378
100	0.081	0.230	0.4693	0.759	1.099	1.543	1.993	2.504	3.053	2.631

Table 2: Predicted file sizes for various combinations of QF_{out} and Z

QF/Z	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10	2355	2765	3281	4001	4763	5586	6597	7722	8754	9979
20	2464	3105	3920	5021	6203	7477	9007	10634	12206	14052
30	2557	3384	4418	5832	7325	8987	10899	12976	14962	17461
40	2628	3592	4821	6490	8249	10205	12493	14886	17281	20306
50	2697	3795	5197	7102	9184	11347	13983	16689	19472	22847
60	2773	4020	5601	7774	10125	12593	15564	18707	21827	26455
70	2876	4355	6204	8749	11496	14438	17987	21698	25484	30972
80	3046	4876	7182	10337	13752	17488	21954	26598	31378	37882
90	3409	5979	9269	13799	18803	24255	30814	37604	44670	54066
100	4771	10273	17806	28381	40457	54013	69936	87160	104856	124888

Table 3: Optimal QF_{out} for various and viewing conditions

$S_{\max}(I,D)/zv(I,D)$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.05	0.1	0.182	0.227	0.244	0.252	0.254	0.254	0.254	0.254	0.254
0.10	0.1	0.199	0.29	0.354	0.395	0.415	0.422	0.425	0.426	0.427
0.15	0.1	0.2	0.299	0.39	0.457	0.488	0.516	0.534	0.54	0.542
0.20	0.1	0.2	0.299	0.395	0.485	0.534	0.567	0.59	0.612	0.622
0.30	0.1	0.2	0.299	0.399	0.496	0.576	0.639	0.679	0.711	0.732
0.40	0.1	0.2	0.298	0.399	0.495	0.586	0.671	0.734	0.775	0.808
0.50	0.1	0.2	0.298	0.395	0.498	0.567	0.657	0.743	0.809	0.885
0.60	0.1	0.2	0.298	0.386	0.499	0.574	0.667	0.739	0.818	0.906
0.70	0.1	0.2	0.299	0.381	0.495	0.598	0.643	0.776	0.826	0.902
0.80	0.1	0.2	0.30	0.382	0.481	0.597	0.685	0.736	0.851	0.972
0.90	0.1	0.2	0.30	0.389	0.466	0.59	0.697	0.737	0.856	0.999
1.00	0.1	0.2	0.30	0.396	0.461	0.57	0.693	0.788	0.818	0.10

Table 4: Optimal $\hat{Z}^*$ for various $S_{\max}(I,D)$ and viewing condition $z_v(I,D)$

$S_{\max}(I,D)/Zv$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.05	73.7	42.2	27.1	24.5	23.7	23.4	23.4	23.4	23.4	23.4
0.10	94.2	74.7	48.1	32.7	27.4	25.6	25.1	24.8	24.7	24.7
0.15	98.6	87.9	71.8	50.9	37.9	33.8	31.6	30.4	30	29.9
0.20	99.2	91.4	83.3	68.4	51	42.4	38.4	36.7	35.3	34.8
0.30	99.2	98.2	90	83.5	73.1	61.8	52	47.1	44.2	42.5
0.40	99.2	99.7	92.2	89.7	82.2	74.4	65.3	57.1	52.3	48.7
0.50	99.2	99.8	96.6	90.6	89.3	83.7	76.3	68	60.9	51.8
0.60	99.2	99.8	99.2	92.7	90	88.5	83	76.5	69.6	59.7
0.70	99.2	99.8	99.9	95.5	90.6	90	87.4	81.2	76.7	67.1
0.80	99.2	99.8	99.9	98.3	92.5	90.2	89.9	86.4	81.4	65.5
0.90	99.2	99.8	99.9	99.6	95.4	90.8	90.1	89	83	70.8
1.00	99.2	99.8	99.9	99.9	97.8	92.5	90.3	89.9	88.1	79.8

Fig. 3: Images with PSNR in dB and bit rate in bpp transcoded by the proposed system

Fig. 4: Illustration of results of the proposed scheme for various *QF* and their *PSNR* in dB and CR values

The results of the proposed transcoding scheme for different values of quality factors are illustrated with images in Fig. 4. The quality of reconstruction in dB along with Compression ratios are quoted along with images. For larger QF, PSNR in dB are found to be better. But it results in more amounts of bits to be delivered in the compressed file. In Fig. 5, the variations in the quality of reconstruction are illustrated along with sample images. It is evident that the low values of *QF* result in the transcoded images in better compression ratios. From

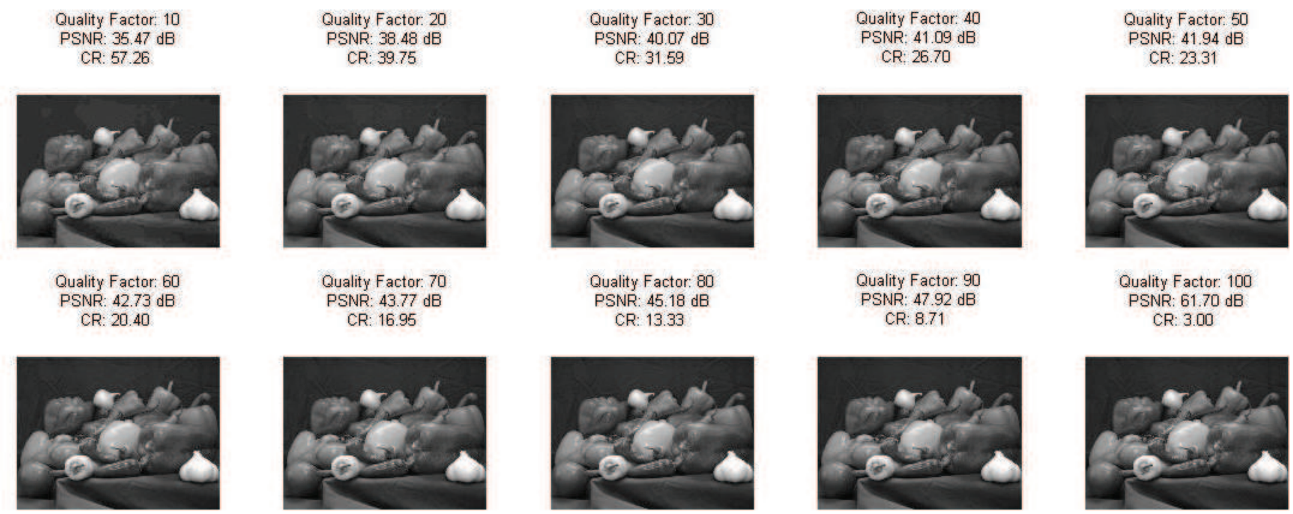

Fig. 5: Transcoded image (peppers.png) results for various *QF* and their *PSNR* in dB and *CR* values

Table 6: Qualitative analysis for various *CR*

CR	PSNR in dB	MSE	SSIM Value
10	44.2596	2.4385	0.9817
20	39.6284	7.0835	0.9598
30	37.0849	12.7231	0.9461
40	35.9226	16.6272	0.9360
50	34.8736	21.1698	0.9277
60	33.8832	26.5924	0.9210
70	33.3342	30.1762	0.9197
80	32.6974	34.9417	0.9131
90	32.1152	39.9537	0.9107
100	31.6483	44.4889	0.9067

Table 6, it is evident that even for less compression ratio i.e. $CR=10$, the $PSNR$ in dB is high ($PSNR=44.2596$ dB). The structural similarity is also high between the input and output images. The SSIM value is 0.9817. The gradual increase in the compression ratio degrades in the quality metrics which is illustrated in Table 6. The performance of the proposed system is compared in Table 7 where transcoding with inter- conversion matrices and directional filter analysis followed by a repositioning algorithm and progressive SPIHT coding outperforms the BDCT-to-DWT conversion followed by SPIHT encoding algorithm.

Table 7: Performance comparison of BDCT-to-DWT+DFB+SPIHT Vs. BDCT-to-DWT+SPIHT

BDCT-to-DWT + DFB + SPIHT		BDCT-to-DWT + SPIHT	
Rate in bpp	PSNR in dB	Rate in bpp	PSNR in dB
0.23	4.36	0.03	3.88
0.27	11.18	0.31	11.60
0.30	16.53	0.33	15.93
0.37	20.35	0.36	19.25
0.50	23.65	0.42	21.64
0.73	26.16	0.57	23.96
1.09	28.61	0.93	26.71
1.71	31.31	1.70	29.90
2.62	34.45	2.81	32.97
3.65	37.12	4.05	34.84
4.78	38.86	5.23	35.47
5.93	39.55	6.34	35.60

5 Conclusion

The proposed approach presents the heterogeneous image transcoding using inter-conversion matrices for the conversion of JPEG to JPEG 2000 along with angular decomposition of wavelet subbands. When comparing with the conventional heterogeneous image transcoding, this method avoids the inverse transform thereby reducing the number of computations. Encoding the results of angular decomposition of wavelet subbands using SPIHT procedure is used to improve the quality of reconstruction and scalability. The results of the proposed system show that there is an improvement of more than 4 dB in the quality of reconstruction for the same bit rate as that of mere DWT-based SPIHT encoding.

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