

# Frontal Facial Image Compression of Hybrid Base

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**Abstract:** Surveillance and security scenarios usually require high efficient facial image compression scheme for face recognition and identification, where Face verification/recognition corresponds to the well-known biometric system. Basically, facial image compression can be regarded as a special application of general image compression technology, in attempt to reduce the number of bytes. The images that are dealt are passport-type photos namely, full face, frontal view, plain background, no dark glasses, without hats and other non-standard clothing.

This paper investigates facial image compression, where simple segmentation process of differencing and thresholding of global base exploited to separate facial from non-facial regions. The hybrid technique based on combination lossless and lossy schemes of mixing between discrete wavelet transform (DWT), predictive coding and hard thresholding quantization techniques. We demonstrate the performance of the proposed system and compare it to other competing algorithm.

**Key words:** Image compression, frontal facial image and ROI.

## 1. Introduction

In the last decade, we have seen a large expansion in the way we communicate through digital media, and still the process is in progress. The enablers include a growing Internet infrastructure with increased bandwidth, storage space and user base; the explosive development of mobile communications; that has led to increasing importance of image and video data in communication. Data compression is one of the technologies used to squeeze data size (i.e., image, video, and audio) to reduce storage and/or communication delay times [1].

Threats to normal life are going on increasing now. In order to reduce the threats, various security measures are in use all over the world. Images of criminals and militants can help the security people to identify them in public gathering places like airports, railway junctions. It is impractical to maintain a complete facial image database at every place. The facial image database maintained in a central data server can be connected by a network to all places that require images for verification or identification purpose. Image compression methods are employed to reduce the facial database storage and transmission costs [2].

Today, various standard image compression systems available these combine efficiency, ease of use and speed like JPEG (Joint Photographic Expert Group), and JPEG-2000 (Joint Photographic Expert Group -2000) [3], but, unfortunately these algorithms (systems) are not specially tailored for the task of facial image compression, namely, these techniques works without considering the facial feature characteristics, where for facial and non-facial regions adopted the same principle regarding the removal of redundancy [4].

Current facial image compression techniques employing segmentation scheme as an elementary vital step to separate the facial image (part) from non-facial image (background), and managing each region solely (independently) according to its importance with preserving image highly quality [2].

This paper is concerned with a typical application of image compression, namely its use in digital passports and ID cards (IDentity card), which is becoming essential in our digital life. The techniques of hybrid based simply utilized the segmentation process that efficiently separates the facial object from the non-facial part (i.e., background), to gain higher compression performance along with preserving highly image quality, the predictive lossless coding exploited for facial image, while the hierarchal DWT of hard threshold based adopted for non-facial image and facial details sub-bands. The

rest of paper organized as follows, sections 2 review some related works, section 3 contains comprehensive clarification of the proposed systems; the results for the proposed system and the conclusions, is given in sections 4 and 5, respectively.

## **2. Literature Survey**

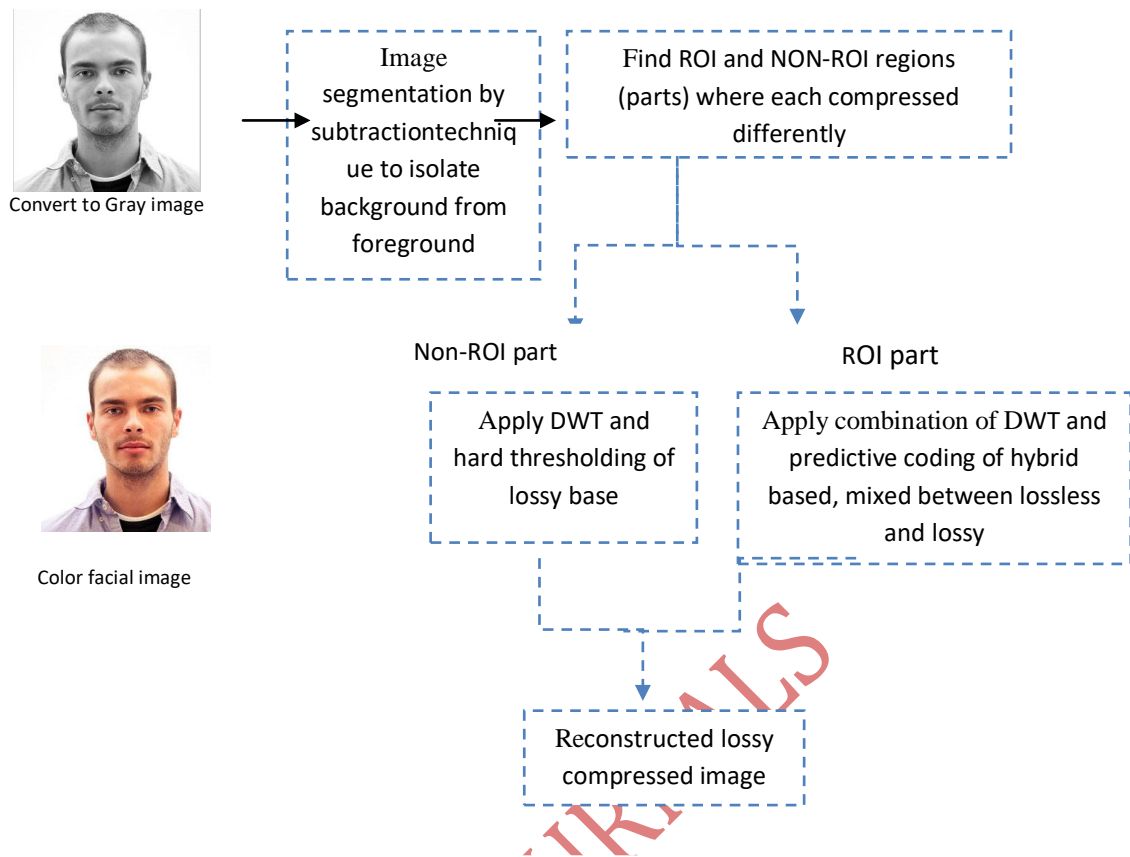
There are many different dominant image compression techniques used today such as run length coding, arithmetic coding, transform coding, vector quantization, predictive coding, polynomial coding, block truncation coding, wavelet and fractal [5], but with increasing demand on face applications, the challenge and necessity of improving facial image compression system performance grew.

Before proceeding to related work review, we have to mention here that most of the work investigated the effects of utilizing the standard compression techniques of JPEG and JPEG-2000 on face recognition system, where Blackburn et. al.[6] measured the effects of image compression of face recognition systems using JPEG technique that tested on FERET( Face Recognition Technology) database, the results showed that compression does not affect recognition significantly across wide range of compression rates, where significant performance drop is noted at 0.2 bits per pixel and below. Also Paul and Vincent [7] clearly showed that JPEG-2000 seems to have less effect on recognition results than JPEG, due to transformation nature, namely the former based on block nature while the latter of quadrants based.

Some researchers keen on face image compression, including Ales [8] adopted the PCA (Principal Component Analysis) which is one of the most widely implemented tools for dimensionality reduction utilized as a tool to compress facial images, the results directly affected by the choice of the number of coefficients used, that affects the image compression ratio and consequently the image quality. A vector quantizer of lossy base is introduced by Elad et. al. [9] to compress facial images efficiently, by break the image into tiles and model each image tile in a compact manner, the results are promising in which the compression rates that are almost twice better compared to the best commercial compression method namely JPEG-2000. Somasundaram and Palaniappan [2] makes use of Canny edge detector for segmenting the background region, further the segmented image is processed with morphological operations to create a ROI (Region Of Interest) mask. The SPIHT (Set Partitioning In Hierarchical Trees) coding is used for encoding wavelet coefficient followed by RLE (Run Length Encoding) for compression. Lastly, Ameer [4] proposed an efficient compression technique of frontal facial images of fixed background using the basis of segmentation, the predictive coding and the combination between the lossy/near-lossless techniques according to facial image regions.

## **3. The Proposed System**

Generally, the government proposes to use biometric data for identification and verification of individuals in e-Governance applications, where the biometric data includes fingerprint image, face image and iris data. The face image would be mainly used for verification of identity of an individual along with other biometric data like fingerprints/iris image data. In case of missing fingerprints/iris data of an individual, it would be used as primary data for identification/verification [10]. The term frontal image corresponds to a basic face image which includes the full head width, all hair in most cases, as well as neck along shoulders with plain background, no dark glasses, and without hats, that applicable to portraits for passport, driver license, and other ID cards [11], where the minimizing the storage requirements of the facial dataset images become an urgent requirement.



**Fig. (1): The Proposed Facial Image Compression System**

**Step 1:** Load input uncompressed frontal facial color image  $I$  of *BMP* format of size  $N \times N$ , as illustrated in figure (2).



**Fig.(2): Original of Uncompressed Facial Color image  $I$ , With Plain Background and Full Frontal Face Details**

**Step 2:** Convert the image  $I$  into grayscale intensity image  $I_{gray}$ , here in MATLAB the built-in function exploited which simply convert the *RGB* color image into gray one as a weighted sum of the  $R$ ,  $G$ , and  $B$  components of *YCrbr* color transformation based model. In other words, the conversion from the color of *RGB* base into gray base utilizes the *YCrbr* model system and the  $Y$  band selected only according to equation (1), which corresponding to the grayscale  $I_{gray}$  [12].

$$I_{gray} = 0.2989 \times R + 0.5870 \times G + 0.1140 \times B \dots\dots\dots(1)$$

Where  $R, G, B$  is *Red, Green, Blue* components of color image bands and  $I_{gray}$  corresponds to source frontal facial uncompressed image of *BMP* format of size  $N \times N$  that shown in figure (3) .

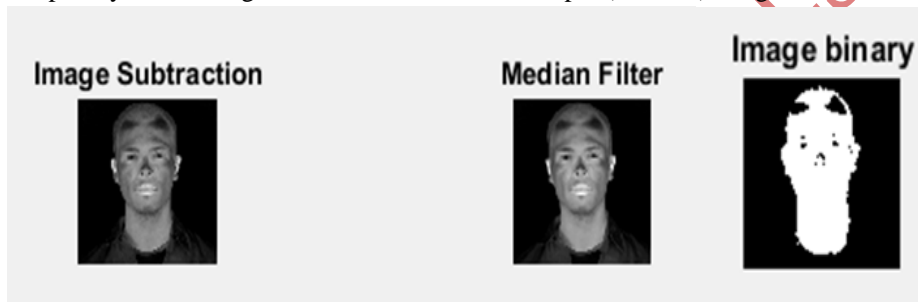


**Fig.(3): Convert to Gray Scale of Uncompressed Facial Color Image  $I_{gray}$ .**

**Step 3:** Apply the difference (subtraction) technique to isolate foreground object (face) from the static background, namely subtract the highly variant band image (source) from the gray image resultant from step above ( $I_{gray}$ ). The source band selected according to standard deviation values, where in all experiments (tests) the source corresponds to *Red* band.

**Step 4:** Use median filter to remove small details from image prior to segmentation process, and bridging of small gaps in lines or curves [12], here the built in function `medfilt2` utilized to perform smoothing process in spatial domain of block size 3x3.

**Step 5:** binaries the enhanced difference image from step above using thresholding techniques, here the `graythresh` function adopted to select the global image threshold automatically to overcome the complexity of choosing a threshold value for each input (selected) image.



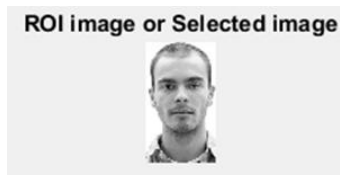
**Fig.(4): Image Segmentation of Subtraction, Median Filter and Binaries.**

**Step 6:** Find the selected region automatically that corresponding to *ROI* using the resultant binary image from the step above, the process starts by finding all face (foreground) points with pixel values equal to ones then finding the maximum and minimum values of both directions (*x* and *y* direction) and lastly computing the width and height of the selected important regions according to equation below [13], figure (5) illustrate the selected *ROI* of facial base.

$$Wid_{ROI} = Maximum_x - Minimum_x \dots \dots \dots (2)$$

$$Hgt_{ROI} = Maximum_y - Minimum_y \dots \dots \dots (3)$$

Where  $Wid_{ROI}$  and  $Hgt_{ROI}$  corresponding to the width and hight of *ROI*.



**Fig. (5) ROI Facial Segmented Image.**

**Step 7:** The non-object base that corresponds to non-facial part, normally compressed using the lossy based techniques, here the *DWT* of hard thresholding utilized for all subbands regardless of subbnads

types (i.e., the techniques applied for approximation and details subbands). Figure (6) shown this step clearly.

1. Apply the DWT of Haar base, that decomposed into approximation subband (LL), and details subbands (LH,HL,and HH).

2. Apply wavelet thresholding process for all subbands resultant from step above using appropriate selected threshold value. Therefore, the choice of wavelet thresholding is an important factor that affected the efficiency, in terms of quality and compression ratio, since these thresholds are used to estimate the level of significant wavelet coefficient as distinct from the level of insignificant wavelet coefficients. The coefficient values larger than threshold are regarded as significant and the values less than the threshold are regarded as insignificant [14].

Here three new methods can be exploited to select thresholding values of hard base for all image details.

**First thresholding technique of Zero/Non-zero base**

- a) Find the number of non-zeros elements for each subband.
- b) Compute the ratio of importance of each band according to equation below.

$$Ratio_{Subband} = factor \times \left( \frac{NumberofNonZeroElements}{SubbandDimension} \right) \dots\dots\dots (4)$$

Where factor is a selected parameter < 0.01.

- c) Find the selected hard threshold value using the computed ratio above and the non-zero elements for each subband.

$$Thr_{NonROI} = \sum_{Subbandi=1}^4 (Ratio_{Subbandi} \times NonZero_{Subbandi}) \dots\dots\dots (5)$$

**Second thresholding technique of Positive/Negative Non-zero base**

In the same way we find the number of positive and negative numbers from non-zero values of each subband, then we compute the ratio as follows, and the thresholded selected as in equation (5).

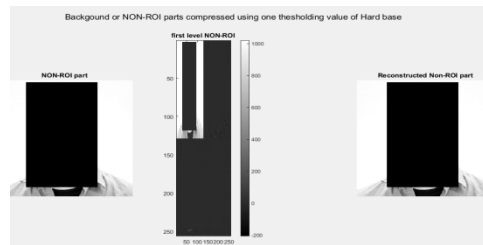
$$Ratio_{Subband} = factor \times \left( \frac{NumberofPositiveElements}{NumberofNegativeElements} \right) \dots\dots\dots (6)$$

**Third thresholding technique of Even/Odd Non-zero base**

The same principle adopted for even/odd numbers, also the threshold selected as in equation (5).

$$Ratio_{Subband} = factor \times \left( \frac{NumberofEvenElements}{NumberofOddElements} \right) \dots\dots\dots (7)$$

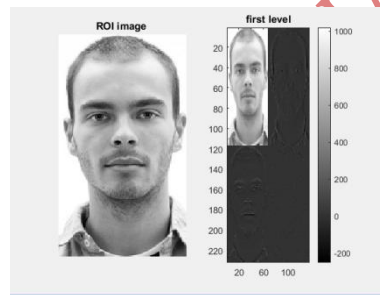
3. Encode/decode the modified subband coefficients using symbol encoding techniques to remove the coding redundancy embedded.
4. Apply the inverse *DWT* to this part of image to reconstruct non-facial image.



**Fig.(6) Non-ROI Compression Using The Hierarchical Scheme of DWT and Hard Thresholding Techniques.**

**Step 8:** The ROI or facial part corresponds to the significant part; here we proposed a combination between the thresholding of lossy base for details subband and lossless predictive coding of approximation subband, the steps below summarizes the technique which also illustrated in figures below (7-9).

1. Apply the *DWT* of one layer decomposition scheme.
2. For details subbands apply the hard thresholding techniques of non-zero based method (see step7 and figure 7).



**Fig. (7): The DWT of ROI Image Part**

3. For approximation subband (LL). apply lossless predictive coding technique of one dimensional causal model ,suchas:

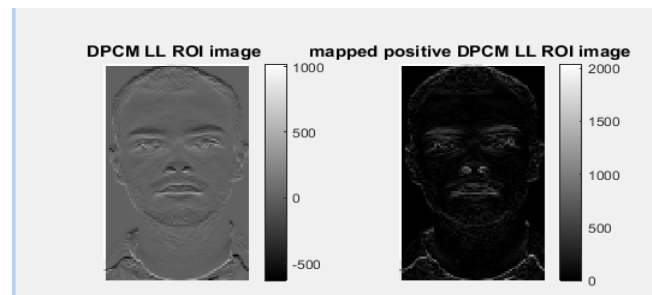
$$\tilde{I}(i, j) = I(i, j - 1) \dots \dots \dots (8)$$

followed by mapping /demapping (inverse mapping) to positive process [11], such as:

$$Map_i = \begin{cases} 2LL_{value} & \text{if } LL_{value} \geq 0 \\ 2LL_{value} - 1 & \text{else} \end{cases} \dots \dots \dots (9)$$

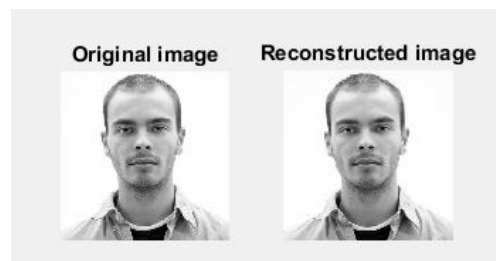
$$InvMap_i = \begin{cases} Map_i / 2 & \text{if even} \\ (Map_i + 1) / 2 & \text{else} \end{cases} \dots \dots \dots (10)$$

Figure (8) illustrate an example of facial image before and after the mapping process.



**Fig. (8): Example of Mapping Process, Where Image to the Left Corresponds to Non-Mapped Image While the Image to the Right Corresponds to the Mapped Image**

4. Apply symbol encoder to code the compressed information of mapped based and hard thresholding scheme, then apply inverse process to reconstruct the compressed image after combined the ROI and non-ROI parts (regions) that shown in figure (9).



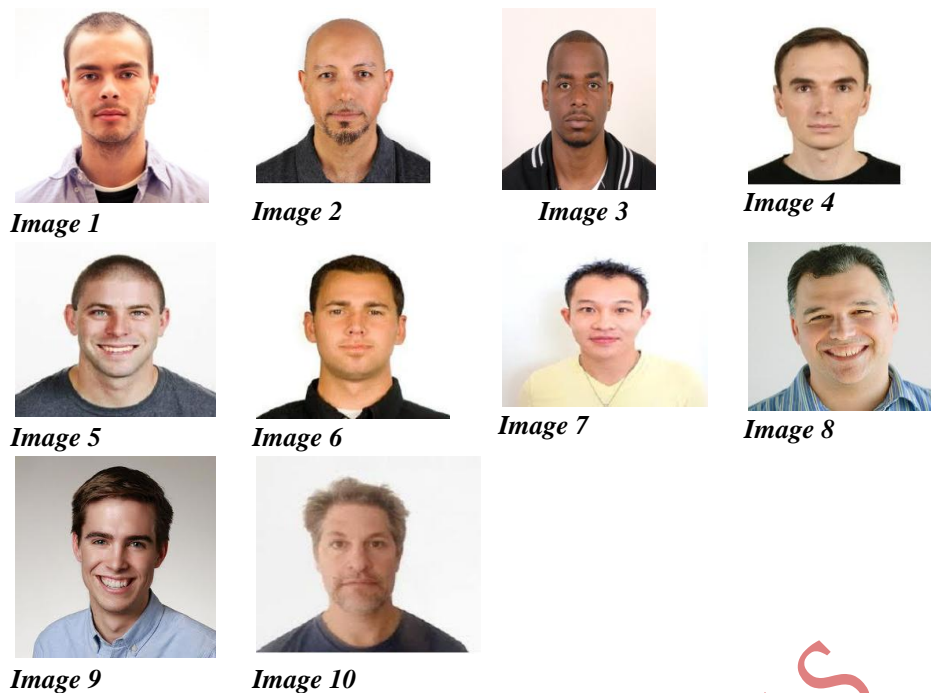
**Fig. (9): The Original and Reconstructed Approximated Images**

**Algorithm (1): The Proposed Frontal Facial Image Compression Algorithm.**

1. Input color image front facial base  $I$  of size  $N \times N$ .
2. Create to gray frontal facial image  $I_{gray}$ .
3. Apply segmentation process of background subtraction to separate (isolate) ROI from Non-ROI.
4. For Non-ROI part, apply lossy base technique of  $DWT$  and hard thresholding techniques.
5. For ROI, apply hybrid techniques of  $DWT$  and predictive coding techniques.
6. Combined the ROI and Non-ROI parts to reconstruct approximated frontal facial image.

#### 4. Experimental Results

In order to test the performance of the proposed (suggested) compression system, the same tested image in [4] adopted (see figure 10), where all of color base (24 bits/pixel) square ( $256 \times 256$ ) images of passport frontal facial with different background, , also all the experiments are based on measuring the compression ratio Compression Ratio ( $CR$ ) and the Peak Signal To Noise Ratio ( $PSNR$ ).



**Fig. (10): The Tested Frontal Facial Images of Size 256×256 .**

Table (1) illustrate the performance of the proposed facial compression system using the three adopted techniques of hard thresholding base schemes with various factor values of ROI and Non-ROI parts.

There are a number of highlight issues need to be mentioned according the above results:

- 1- The trade off or the inverse relation between the compression ratio and the decoded image quality is clearly shown, where for low compression ratio attains the high PSNR value, and vice versa.
- 2-Obviously, the factors of ROI/Non-ROI affect both the compression ratio and the appearance of the decoded image quality, where the ROI factor attempts to preserve image quality, while the Non-ROI factor achieved higher compression performance due to large background area (Non-ROI) compared to ROI (facial) part.
- 3- The results vary according to the facial image characteristics (details).
- 4- Finally, the performance is strongly affected by the techniques utilized and the used factors of ROI/Non-ROI, where in most cases the third and first techniques produce the high performance.

A comparison in performance is illustrated in table (2) between the suggested techniques and Ameer work adopted in [4], where the comparison depends on high PSNR attained.

Table (1): The Proposed System Performance Using Different Factor Values of ROI/Non-ROI for Tested Images

Tested Images	ROI Factor	Non ROI Factor	Technique1			Technique2		Technique3
			CR	PSNR	CR	PSNR	CR	PSNR
Image 1	0.0001	0.0001	12.091513	42.152757	12.805002	42.139329	15.485822	41.422171
		0.001	14.648190	41.551247	15.485822	41.422171	16.701325	37.032135
	0.001	0.0001	14.881017	41.866869	15.708533	41.539554	19.944005	40.908517
		0.01	16.641950	38.085644	23.865987	34.152450	35.234409	34.030227
Image 2	0.0001	0.0001	14.499115	29.202562	14.694170	29.202426	16.425063	29.133709
		0.001	19.504762	29.155673	15.761424	29.186314	17.522995	24.885081
	0.001	0.0001	15.276457	29.198446	19.859394	29.155538	23.157597	29.087553
		0.01	16.726901	29.039188	33.642710	28.109738	44.341001	28.056213
Image 3	0.0001	0.0001	11.021863	61.740302	12.946661	57.526212	14.234579	53.049075
		0.001	13.112445	51.152782	14.807049	48.014872	15.219693	39.557741
	0.001	0.0001	14.674429	49.551217	15.929995	50.571767	17.925602	49.224715
		0.01	15.906796	29.216341	22.962859	37.538614	27.352254	37.460763
Image 4	0.0001	0.0001	19.040093	45.311970	19.366430	45.308028	20.791878	43.250217
		0.001	26.511327	44.734793	20.441672	44.922586	21.389034	29.114424
	0.001	0.0001	20.017104	45.242162	27.148302	44.731342	30.034830	42.882271
		0.01	20.818297	42.636468	46.413598	37.888168	55.538983	37.435742
Image 5	0.0001	0.0001	14.378236	54.315083	14.595991	54.247690	17.466951	45.570076
		0.001	18.194336	50.083061	16.761125	48.340861	18.618182	33.109454
	0.001	0.0001	15.791807	51.842928	18.544426	50.057504	23.439199	44.705593
		0.01	18.306145	40.793194	28.223945	37.124371	41.373737	36.618112
Image 6	0.0001	0.0001	16.869642	75.093045	17.365130	72.234461	19.458432	48.401947
		0.001	22.520962	53.693100	19.040093	52.677050	20.778694	29.187486
	0.001	0.0001	18.440068	58.464432	23.422445	53.632757	27.397993	47.276826
		0.01	19.787440	42.470196	38.013921	38.845835	49.723824	38.391419
Image 7	0.0001	0.0001	18.044053	61.054239	21.473132	58.379047	23.676301	49.671118
		0.001	20.441672	58.664319	23.744928	48.903461	24.344725	35.639219
	0.001	0.0001	23.059817	54.236458	24.956588	56.929209	27.982921	49.445333
Image 8	0.0001	0.0001	14.1607 61	58.976430	14.160761	55.805621	15.822308	46.238533
		0.001	18.8105 63	50.835392	14.989936	55.281312	17.273590	30.160873
	0.001	0.0001	14.7338 13	59.649183	18.810563	50.835392	21.859907	44.944897
			16.5327 95	40.141858	29.153025	34.849907	37.194098	34.545393
Image 9	0.0001	0.0001	13.1492 78	51.531345	14.340481	51.417726	16.633503	47.121050
		0.001	15.0796 13	49.680552	16.633503	46.121050	17.712432	36.203919
	0.001	0.0001	16.1180 52	49.153427	16.667345	49.606022	19.847365	46.356572
			17.5888 35	38.776575	26.235388	36.072946	35.083512	35.863748

<b>Image 10</b>	0.0001	0.0001	16.5411 41	46.520379	17.264489	46.565352	20.467208	44.474015
		0.001	21.1679 59	46.038521	20.314941	44.974648	21.487213	27.639551
	0.001	0.0001	19.3893 49	46.043897	22.276003	46.076550	27.911414	44.165585
	0.01		20.6999 37	41.450894	34.097815	40.256655	49.349398	39.669666

Table (2): The Comparison Performance Between the Proposed System and Ameer system [4].

Tested images	Proposed system	Ameer system in [4]
<b>Image 1</b>		
CR	16.541141	10.9849
PSNR	46.520379	48.2572
<b>Image 2</b>		
CR	19.504762	11.9635
PSNR	39.155673	47.8819
<b>Image 3</b>		
CR	11.021863	9.4324
PSNR	61.740302	48.8212
<b>Image 4</b>		
CR	19.040093	15.0727
PSNR	45.311970	47.7902
<b>Image 5</b>		
CR	14.378236	11.0108
PSNR	54.315083	48.7599
<b>Image 6</b>		
CR	22.520962	12.6371
PSNR	53.693100	47.7922
<b>Image 7</b>		
CR	18.044053	13.5967
PSNR	61.054239	48.2247
<b>Image 8</b>		
CR	18.810563	7.6974
PSNR	50.835392	48.5113
<b>Image 9</b>		
CR	13.149278	9.2827
PSNR	51.531345	48.6136
<b>Image 10</b>		
CR	21.167959	13.4571
PSNR	46.03852	48.5369

The results clearly illustrates the better performance in *CR* and nearly approximated quality of [4], that due to the mixing between hybrid coding of lossy/lossless base and incorporating the *DWT* of hard thresholding, on the other hand the results of [4] involves the near-lossless and lossy techniques that affected both the quality and compression ratio, which implicitly affected by error tolerance.

## **5. Conclusions**

- 1- The proposed technique of hybrid base achieved high performance in terms of compression ratio and quality, due to the mixing of lossless and lossy methods, and directly affected by the thresholding value selected.
- 2- The hierarchal scheme of DWT along the hard thresholding techniques, improve the compression ratio, retaining the image quite visually pleasing without visual degradation.
- 3- The segmentation process efficiently isolates the ROI (face) from the Non-ROI (background) that implicitly enhances the performance of the proposed system.

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