THE EFFECT OF WAVELET COEFFICIENT REDUCTION ON IMAGE COMPRESSION USING DWT AND DAUBECHIES WAVELET TRANSFORM

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ABSTRACT: With the advent of digital information age there has been ever increasing demand of intensive multimedia based web applications, efficient techniques for encoding of images and signals. There are stronger efforts to develop better compression techniques with the sole objective to produce high compression performance while minimizing the amount of image data. Image compression is a technique to reduce redundancy and irrelevancy of image data to enable its efficient transmission and storage. In this paper a method for compressing is by wavelet transform filters based on wavelet difference reduction WDR on the color images. The multimedia file used in this research as uncompressed media file is image bitmap (Bmp) file of dimensions (512×512). The images are compressed and then decompressed by using different types of wavelet filters the Daubechiec9/7 and Haar wavelet transform with number of level is 4. Different compression parameters were displayed including MSE, PSNR, and CR for the comparison of best possible results between the original image and the compressed image. The experimental results are compared with compression results of both JPEG and JPEG2000 standard.

Key words: Image Compression, Wavelet Transform, Peak signal to noise ratio (PSNR), Mean squared error (MSE), Compression Ratio (CR).

1. INTRODUCTION

Image compression is one of the stages involved in the process of image storage and retrieval that has generated huge interest among researchers. The main objective behind image compression is to effectively reduce redundancy and irrelevancy of the image data so that data is effectively transmitted and stored. [1]

Image compression is a fast-evolving field and as such many varieties of compression methods are available. Broadly, it is possible to compress image through lossy procedure that includes transform coding such as Wavelet transform such as Haar and Daubechies 9/7. Haar wavelet basis used to represent the selected images by computing a wavelet transform. By calculating the average pixels together to get the new lower resolution image with new pixel values then to recover the original four pixel values from the two averaged values [2 and 3]. Biorthogonal Daub (9/7) was presented by Cohen, Daubechies, and Feauvea [4 and 5]. It also named (tap9/7) because of the filter lengths are 9 and 7 for low and high pass filters, respectively. The term difference reduction refers to the way in which WDR encodes the locations of significant wavelet transform values. The Wavelet Difference Reduction WDR algorithm is a very simple procedure for image compression. A wavelet transform is first applied to the image, and then the bit-plane based WDR encoding algorithm for the wavelet coefficients. The compressed data operations are possible with the Wavelet Difference Reduction (WDR) algorithm [6 and 7]. Three Compression Efficiency Parameters were implemented .These are CR, MSE, and PSNR values for the images compressed. The aim of this research is to compare of HAAR and Doub.9/7 wavelet transform. Peak signal to noise ratio (PSNR), mean square error (MSE), and compression ratio (CR) have been calculated to determine how well an image is reproduced.

2. MATERIALS AND METHODS

The operations is started by applying and loading the input colored image, as a second step the wavelet transform will be applied with different filters Haar and Daub9/7 wavelet transform. Then, quantization process is performed to decrease the elements of large set to smaller set, the benefits obtained from this conversion is to reduce the number of bits required to represent all possible values outputs to fewer bits with verification .After quantization the scanning step is performed and wavelet difference reduction technique is applied with binary encoding to get the compressed image. [8].

2.1 Biorthogonal Daub9/7

Wavelet Biorthogonal co-efficient for wavelet decomposition can perform better to reconstruct image with higher PSNR, CR and low MSE [1 and 4]. To compute the (9/7) wavelet of an array x of m samples, where ($0 \leq n \leq m/2$) the following equations are used:

(a)Lifting Step

$y(n+1)=y(n+1)+a[y(n)+y(n+2)]$ all odd n in the range

$y(n)=y(n)+b[y(n-1)+y(n+1)]$ all even n in the range

$y(n+1)=y(n+1)+c[y(n)+y(n+2)]$ all odd n in the range

$y(n)=y(n)+d[y(n-1)+y(n+1)]$ all even n in the range

(b)Scaling Step, K is the scaling factor

$y(n+1)=k*y(n+1)$ all odd n in the range

$y(n)=(y(n))/k$

By reversing the transform operation this can be used to obtain the inverse wavelet transformation, the values of the five coefficients are listed in Table 1 [9].

Table 1 Daub9/7 wavelet filter coefficients [9]

Coefficient	Value
a	−1.586134342
b	-0.05298011854
c	0.8829110762
d	0.4435068522
k	1.230174105

2.2 Haar Wavelet

Applying Haar Wavelet technique two neighboring samples (a and b) of a sequence numbers are considered and have some correlation. The simple wavelet transforms which replaces (a and b) by the average s and difference d is done according to the following equations: [1 and 3]

$S = (a+b)/2$

d=b-a

The idea is that if a and b are highly correlated, the expected absolute value of their difference d will be small and can be represented with fewer bits. In case that a = b the difference is simply zero. No loss in any information will occur because given s and d could be always recovered a and b as follows: [2 and 4].

a=s-d/2

b=s+d/2

The above two equations is the key behind the so-called Haar wavelet transform.

2.3 Wavelet Difference Reduction WDR

In WDR, the output from the significance pass consists of the signs of significant values along with sequences of bits which concisely describe the precise locations of significant values with five steps [7 and 8].

A- An assignment of a scan order was made. For an image with P pixels, a scan order is a one-to-one and onto mapping $\hat{F}$_(i,j)=X_k , for k=1, 2,.,P between the wavelet coefficient and a linear ordering(X_k).

B- Updating threshold by dividing it by two.

C-Using the difference reduction method that consists of a binary encoding of the number of steps to describes the precise locations of significant values.

D- Adapting the Refinement pass to generate the refined bits via the standard bit-plane quantization procedure.

E-Repeating the steps from the B to D until reaching the final bit.

2.4 Compression Efficiency Parameters

The Compression Efficiency Parameters CR, MSE, and PSNR are calculated by using the following formulas [8].

A- CR is the ratio of original image bit stream to compressed image bit stream:

$$CR = \frac{Total\ number\ of\ bits\ in\ original\ image}{Total\ number\ of\ bits\ in\ compresses\ image}$$

B-MSE is defined as follow:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{i=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Where:

I (i, j) is the value of original image at row (j) and column (i).

K (i, j) denotes the reconstructed image pixel value at the locations (i), and (j).

C-PSNR

The low value of PSNR indicates the poor image quality. In general, a better reconstructed image is one with small MSE and high PSNR. The PSNR is defined as:

$$PSNR = 10\log 10\,(\frac{MAX^2}{MSE})$$

2.5 Images used in the Experiments

The images Baboon, Fruits and Peppers are applied for the tests with dimensions of (512*512). The original bmp images are shown in (Figure 1). The results of tests are applied to get the Peak Signal to Noise Ratio (PSNR) amounts, compression ratio (CR) and the Mean Square Error (MSE) amounts from the rebuild images.

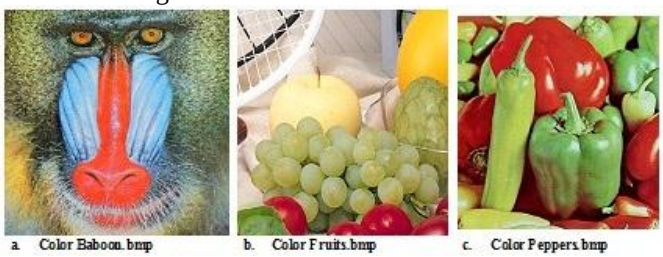


Figure 1: The Original Tested Images

3. RESULTS AND DISCUSSION

Using visual basic programing, the WDR technique is implemented with level four of Daubechies 9/7, and Haar wavelet transform filters on the three images, Baboon, Fruits and Peppers of dimension (512×512) [8]. Efficiency parameters are calculated to be compared with their qualities. The findings of applying the wavelet transform process, quantization, scanning, WDR and binary encoding indicate that for different quantized bit (QB) there were various CR, MSE and PSNR for each filter, and tested image [8].

The findings of applying Daubechies 9/7, and Haar filters with level four on the three images, reflect that increasing the QB value lead to decreasing of CR value that effect the PSNR and MSE (Table 2). Actually, it was found that the optimum value is 0.8 which will be essential to give more reliable MSE and PSNR values. In other words, beneath the optimum value, the images will be distorted for different applied filters. It is obvious from the results that the Daub9/7 wavelet filter is better than the Haar wavelet filter (Table 2).

Applying the Daub9/7 for the color Baboon image the (QB 3, 1.6, and 0.8) gave (CR 8.0, 14.99 and 29.99), (PSNR 26.302, 24.11, and 22.235), (MSE 152.332, 252.31, and 388.628) respectively. Such findings reflect that the higher CR indicate with (QB 0.8) and reflect MSE and PSNR values are relatively better with higher CR. While using Haar for the color Baboon image indicate that (QB 3 gives CR 8.0, PSNR 24.44, and MSE 185.65). While (QB 1.6, gives CR 14.99, PSNR 23.581, and MSE 285.07), but (QB 0.8 shows that CR 29.99, PSNR 21.655, and MSE 444.101) respectively. Such findings reflect that the values of PSNR and MSE using Haar wavelet transform is relatively not so good which give MSE higher than MSE with Daub9/7 and less PSNR than with Daub9/7. The same results are true for color Fruits and Peppers images. (Table 2). Moreover, the results of PSNR is getting higher in Daub9/7 and lowering of the MSE values, much better than the Haar wavelet. So the reconstructed images would be clearer in Daub9/7.

3.1 Comparisons with JPEG and JPEG2000

Comparisons were made between Daub9/7, and Haar filters with WDR and the standard JPEG and JPEG2000 that were indicated by applying ACDsee7.0 [11], to measure the efficiency performance of the tested images (Figure 1).

The results of the tested images with levels 4 (NL) wavelet transform after comparison with standard coders of dimension (512×512) are closer to the standard JPEG more than JPEG2000 (Tables 3, 4 and 5). In addition, the results of CR were plotted against PSNR and MSE to show their relationships graphically for the tested images, the plots of CR versus PSNR show negative relation while the plots of CR versus MSE show positive relation. Both indicate the close relation between proposed method and standard JPEG. The Daub9/7 wavelet filters is closer to the standard coders in results (Figures 2, 4 and 6) rather than the Haar wavelet filter (Figures 3, 5 and 7).

Table 2 The findings of applying Daubechies 9/7, and Haar filters with level four on the three images, Baboon, Fruits and Peppers of dimension (512×512).

Image 512×512	QB	CR	Daub 9/7 Wavelet Transform		Haar Wavelet Transform	
			PSNR	MSE	PSNR	MSE
Color Baboon	0.8	29.99	22.235	388.628	21.655	444.101
	0.9	26.66	22.53	363.112	21.876	422.14
	1.1	21.817	23.09	318.53	22.398	374.304
	1.6	14.99	24.11	252.31	23.581	285.07
	2.3	10.43	25.1	201.33	24.49	231.22
	3	8.0	26.302	152.332	24.44	185.65
Color Fruits	0.8	29.99	32.256	38.676	30.06	64.02
	0.9	26.66	32.517	35.4201	30.41	59.05
	1.1	21.817	32.94	32.97	31.671	44.25
	1.6	15.0	34.65	22.25	32.63	35.48
	2.3	10.43	35.53	18.16	34.33	23.97
	3	8.0	36.4432	14.748	35.11	20.04
Color Peppers	0.8	29.99	34.852	21.249	31.182	49.52
	0.9	26.66	33.743	19.212	31.59	45.02
	1.1	21.817	36	16.32	33.02	32.43
	1.6	15.0	38.33	9.53	34.7	22.02
	2.3	10.43	40.69	5.53	36.96	13.08
	3	8.0	41.751	4.344	38.402	9.39

Table 3 Comparison between standard coders (JPEG & JPEG2000) and Daub9/7, Haar Wavelet Transform Filters on color Baboon image of dimension (512×512)

Compression Method	CR Controlled Parameter		CR	PSNR	MSE
Standard JPEG	Quality				
	70%		7.84	26.52	144.69
	55%		10.09	25.714	174.4
	25%		14.6	24.64	223.1
	5%		17.5	24.14	250.39
Standard JPEG2000			8.0	28.39	94.12
			10.0	27.489	115.915
			15.0	25.99	163.38
			21.0	24.85	212.58
Proposed Daub9/7 Filter Method	NL	QB			
	4	3	8.0	26.302	152.332
		2.3	10.4	25.1	201.33
		1.6	15.0	24.11	252.31
		1.1	21.8	23.09	318.53
Proposed Haar Filter Method	NL	QB			
	4	3	8.0	24.44	185.65
		2.3	10.4	24.49	231.22
		1.6	15.0	23.581	285.07
		1.1	21.8	22.398	374.304

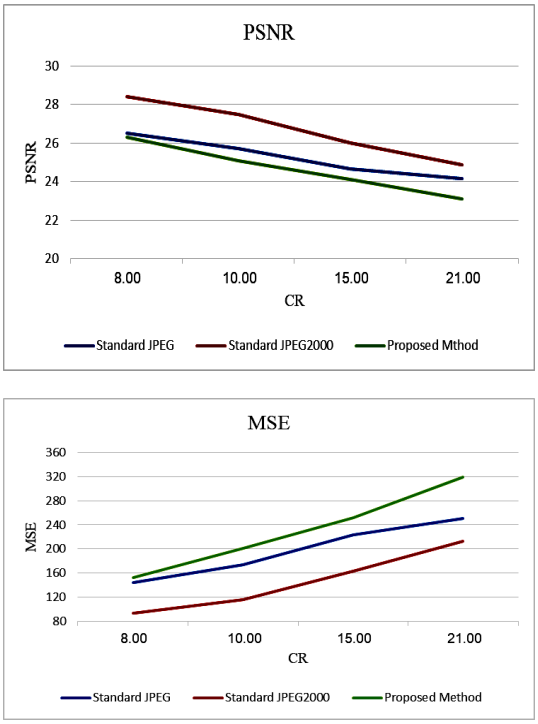
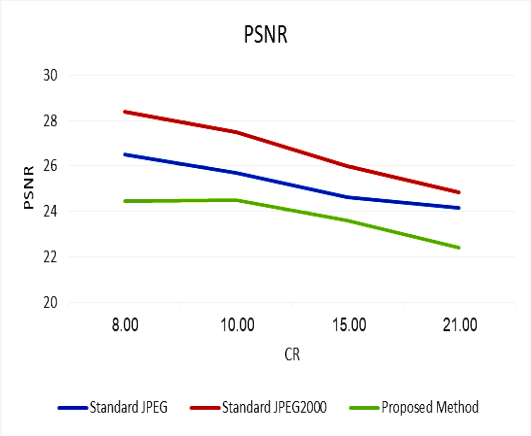


Figure 2 Graphical plot between compression ratio versus PSNR and MSE of the results of level 4, Daub9/7 wavelet filter for Baboon image of dimension (512×512)



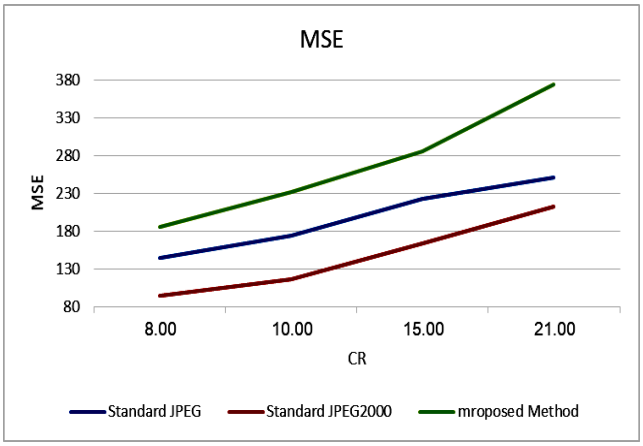
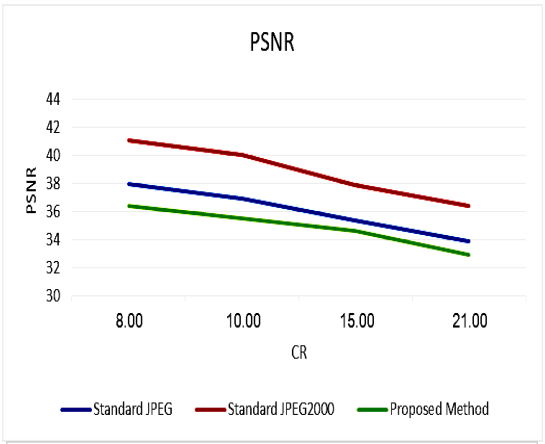


Figure 3 Graphical plot between compression ratio versus PSNR and MSE of the results of level 4, Haar wavelet filter for Baboon image of dimension (512×512)

Table 4 Comparison between standard coders and Daub9/7, Haar Wavelet Transform Filters on color Fruits image of dimension (512×512)

.Compression Method	CR Controlled Parameter		CR	PSNR	MSE
Standard JPEG	Quality				
	90%		7.78	38.015	10.26
	85%		10.37	36.95	13.1
	73%		14.6	35.37	18.87
	53%		21.0	33.94	26.21
Standard JPEG2000			8.0	41.12	5.023
			10.0	40.041	6.44023
			15.0	37.91	10.5
			21.0	36.47	14.62
Proposed Daub9/7 Filter Method	NL	QB			
	4	3	8.0	36.443	14.748
		2.3	10.4	35.53	18.16
		1.6	15.0	34.65	22.25
		1.1	21.8	32.94	32.97
Proposed Haar Filter Method	NL	QB			
	4	3	8.0	35.11	20.04
		2.3	10.4	34.33	23.97
		1.6	15.0	32.63	35.48
		1.1	21.8	31.671	44.25



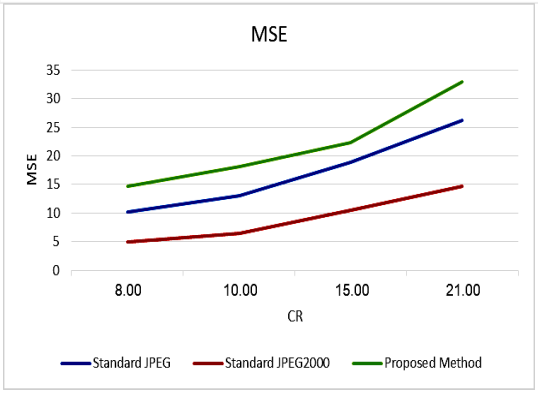
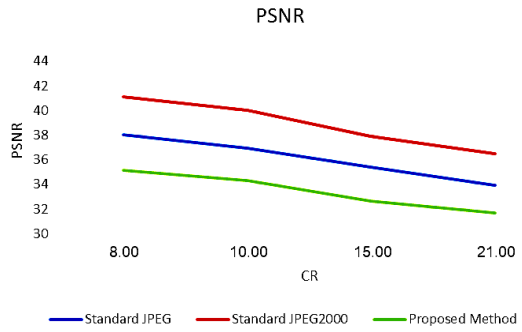


Figure 4 Graphical plot between compression ratio versus PSNR and MSE of the results of level 4, Daub9/7 wavelet filter for Fruits image of dimension (512×512)



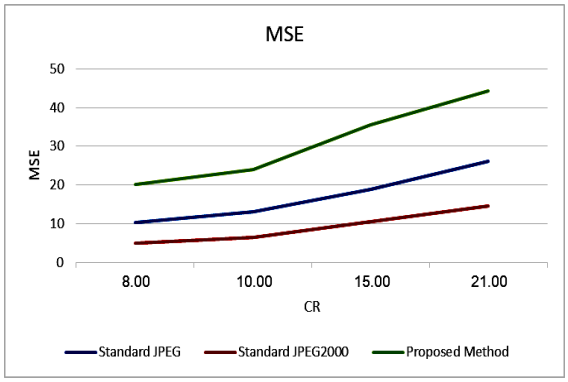


Figure 5 Graphical plot between compression ratio versus PSNR and MSE of the results of level 4, Haar wavelet filter for Fruits image of dimension (512×512)

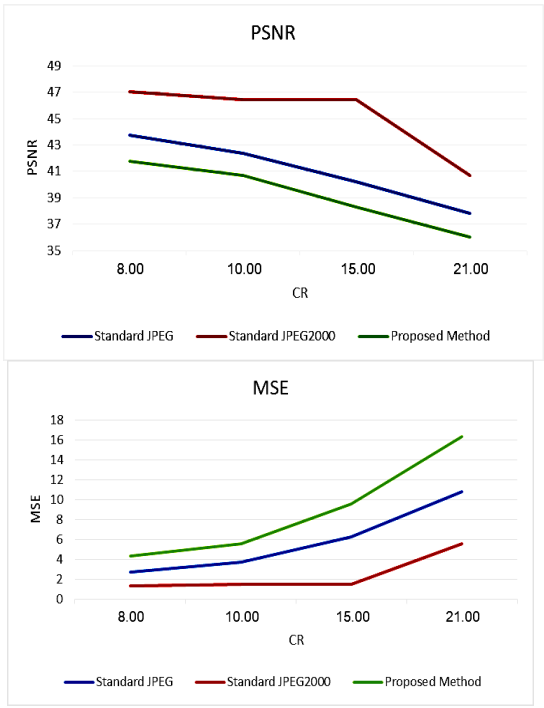


Figure 6 Graphical plot between compression ratio versus PSNR and MSE of the results of level 4, Daub9/7 wavelet filter for Peppers image of dimension (512×512)

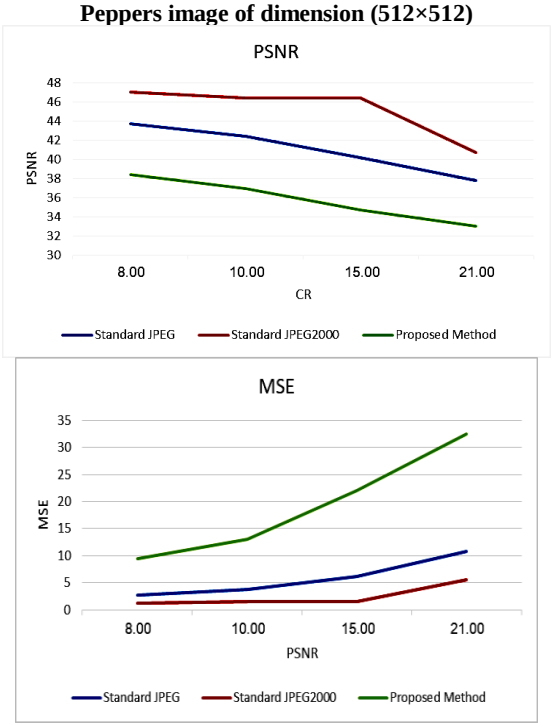


Figure 7 Graphical plot between compression ratio versus PSNR and MSE of the results of level 4, Haar wavelet filter for Peppers image of dimension (512×512)

TABLE 5: COMPARISON BETWEEN STANDARD CODERS AND DAUB9/7, HAAR WAVELET TRANSFORM FILTERS ON COLOR PEPPERS IMAGE OF DIMENSION (512×512)

Compression Method	CR Controlled Parameter		CR	PSNR	MSE
Standard JPEG	Quality				
	90%		8	43.74	2.74
	85%		10	42.392	3.74
	73%		15	40.19	6.21
	50%		21	37.81	10.77
Standard JPEG2000			8	47.04	1.283
			10	46.44228	1.475204
			15	46.44	1.47
			21	40.68	5.54
Proposed Daub9/7 Filter Method	NL	QB			
	4	3	8.0	41.751	4.344
		2.3	10.4	40.69	5.53
		1.6	15.0	38.33	9.53
		1.1	21.8	36	16.32
Proposed Haar Filter Method	NL	QB			
	4	3	8.0	38.402	9.39
		2.3	10.4	36.96	13.08
		1.6	15.0	34.7	22.02
		1.1	21.8	33.02	32.43

CONCLUSION

The implementation steps of the methods for image compression system by using visual basic programming was designed to handle the color images Baboon, Fruits and Peppers as media file bitmap (Bmp) file of dimensions (512×512). The images were compressed and then decompressed by using different types wavelet transform filters the Daub9/7 and Haar wavelet transform, based on WDR with levels 4. Compression parameters were displayed including MSE, PSNR, and CR. The results reflect that the PSNR value is getting higher in Daub9/7 and lowering of the MSE values, much better than the Haar wavelet. So the reconstructed images would be clearer in Daub9/7.

The experimental results were compared with compression results of both JPEG and JPEG2000 standard. The Daub9/7 was found better results and has clearer reconstructed image more than the Haar wavelet transform, and when the quantized bit (QB) is getting smaller the CR is coming higher with different PSNR and MSE. Comparing with the standard coders it was found that the Daub9/7 is much closer to standard coder and especially with the JPEG standard.

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