Image Transforms for Data Compression

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1. Introduction

Computer assignments aim to transform the same image "Pepper" with two different approaches: DCT and DWT. Also, computer assignments presented the option to use these two approaches as data compression. Moreover, for DCT methods finding the SNR of the original image and transform. Furthermore, the report presented a comparison between DCT and DWT. All goals were accomplished using MATLAB code [1].

2. Theory

a. DCT approach

The algorithm for DCT transforms several steps. The first step was to partition the original images into 8x8 and 16x16 non-overlapping blocs [2]. The second is to change each bloc using DCT [3] (1).

$$X(k,l) = \begin{cases} \frac{1}{N}\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} x(m,n) & \begin{matrix} k,l=0 \\ m,n \in [0,N-1] \end{matrix} \\ \frac{2}{N}\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} x(m,n)\cos[\frac{(2m+1)k\pi}{2N}]\cos[\frac{(2n+1)l\pi}{2N}] & \begin{matrix} k,l \neq 0 \\ k,l \in [0\,,N-1] \\ m,n \in [0\,,N-1] \end{matrix} \end{cases} \quad (1)$$

The third step was to use the energy-based criterion for each i,j bloc to reduce the image data (2).

$$if\ \left|X(k,l)_{i,j}\right| < \max\left(X(k,l)_{i,j}\right) \Rightarrow X(k,l)_{i,j} = 0\ for\ all\ i,j \quad (2)$$

The last step was to join the inverse received matrix (3) to join it to the full image.

$$x(m,n) = \frac{1}{N}X(0,0) + \frac{2}{N}\sum_{\substack{k=0,l=0 \\ k,l\neq 0}}^{N-1} X(k,l)\cos[\frac{(2m+1)k\pi}{2N}]\cos[\frac{(2n+1)l\pi}{2N}] \quad (3)$$

b. DWT Approach

The algorithm for DWT transforms presented in Figure 1 [4].

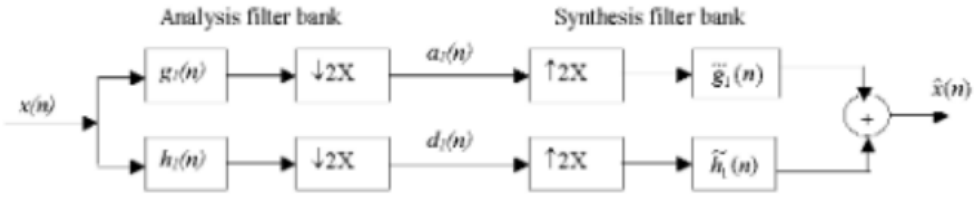

Figure 1 The DWT transforms and reconstructs the image

The h(n,m) and g(n,m) is HP and LP filters respectively.

3. Results and discussion

a. DCT approach

The Matlab code provides an algorithm for DCT transforms for 8x8 and 16x16 blocs with energy-based criteria. The reconstruction for these two types of the bloc is presented in Figure 2.

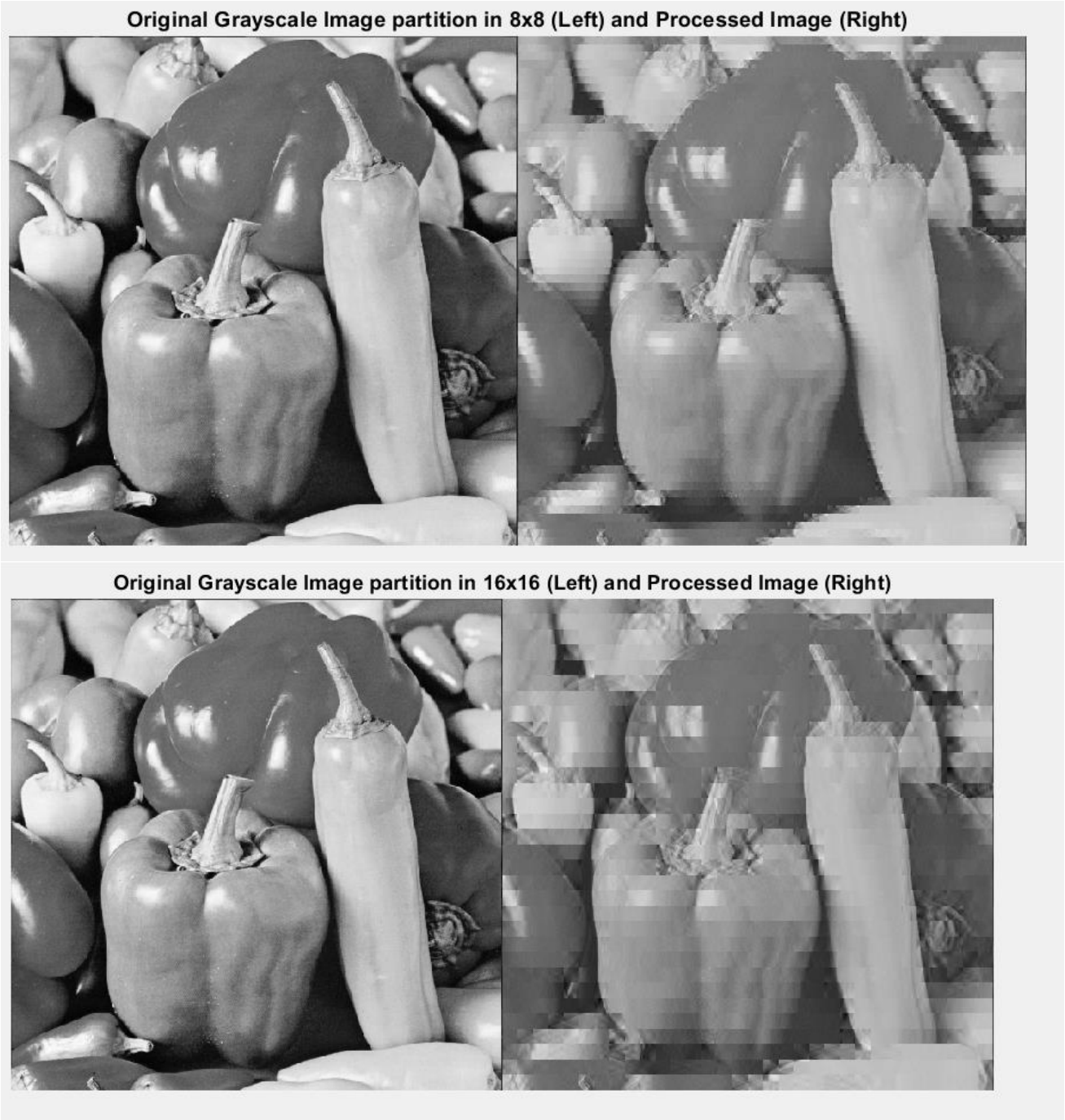

Figure 2 The original and reconstructed image for 8x8 and 16x16 blocs

The standard features are saved from the original images. The reconstructed images are reduced data for each block because of the criterion since the algorithm use only a few DCT parameters. This allows the user to compress the images. The memory size of the reconstructed and original image is presented in Table 1.

image	original	8x8	16x16
Memory size (Kb)	226	209	203

Table 1 The architecture of models.

The peak SNR and SNR are presented in Table 2. The presented result shows that the error between the original image is enough to use this method as a compression method.

Image	8x8	16x16
PSNR	21.16	20.16
SNR	16.88	15.42

a. DWT Approach

The DWT algorithms use the Wavelet Toolbox, in particular the waveletAnalyzer. The computer assignments presented two-level and three-level decomposition with different wavelets. The first one is two-level and three-level Daubechies (db4) (Fig 3). The histogram is presented in Figure 4.

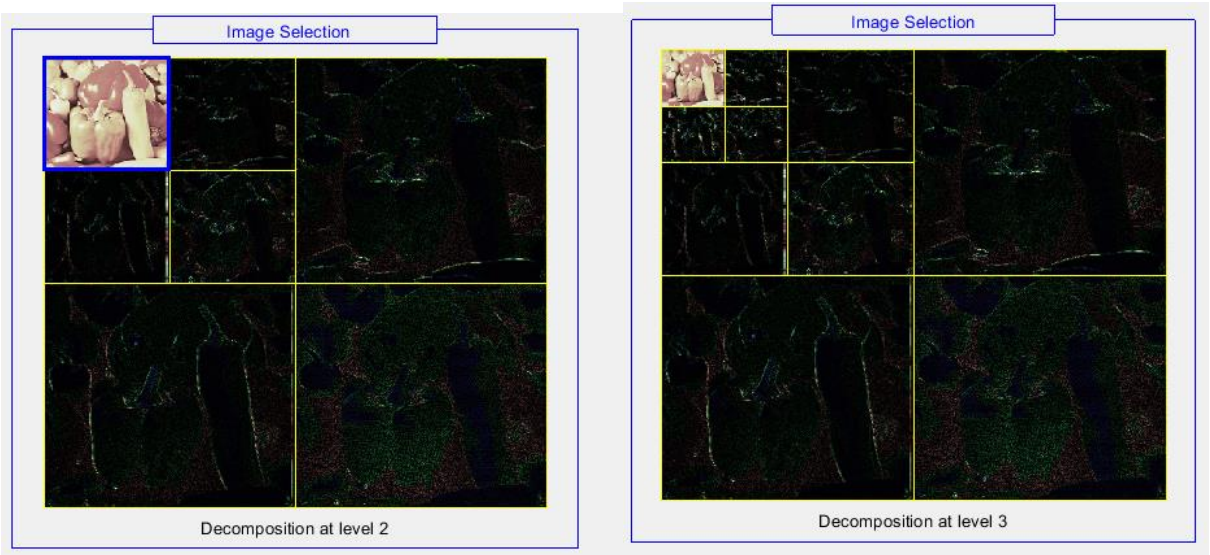

Figure 3 The two-level and three-level decomposition db4

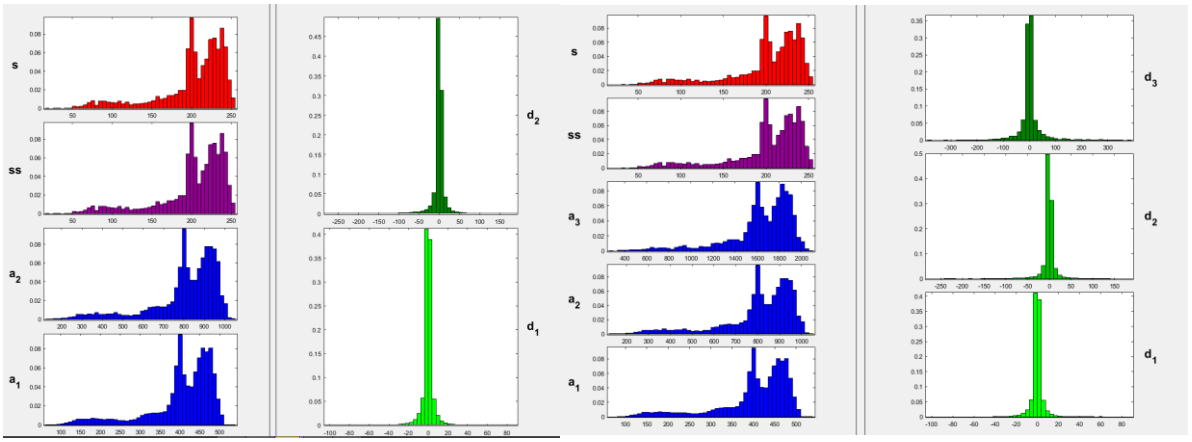

Figure 4 The left histogram is two-level, and the right is three-level where s-original image; ss-synthesized; a1, a2, a3 –approximation for level;d1, d2, d3 –detail for level.

The second is a two-level and three-level Symlet (sym) presented in Figure 5. The histogram is presented in Figure 6

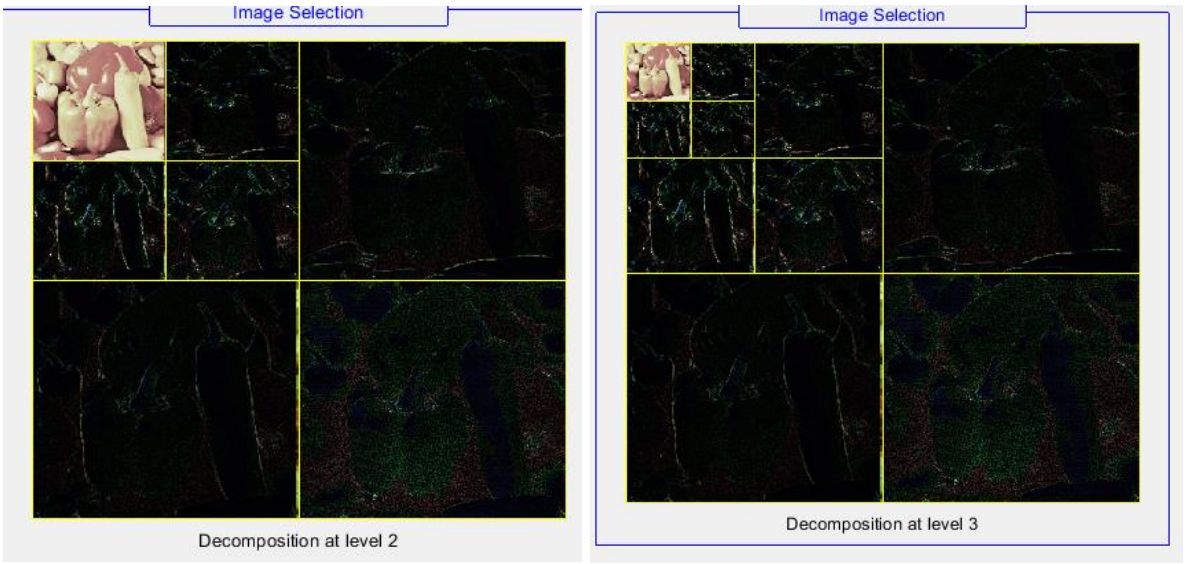

Figure 5 The two-level and three-level decomposition sym

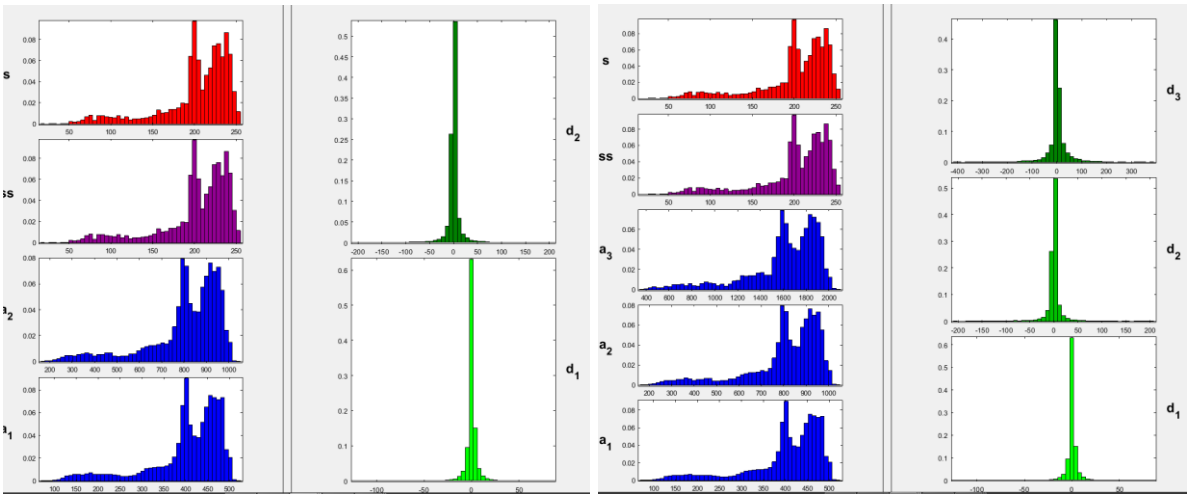

Figure 6 The two-level and three-level decomposition sym histogram

The best result for all transformations was a two-level Symlet. The approximation coefficient is presented with 16x16 DCT in Figure 7.

Figure 7 The comparison of two images.

4. Conclusion

The computer assignments show how to reduce the image without losing critical information. Also, the computer assignments show that DWT is better than the DCT method. The DWT could compress more by order than DCT without losing critical information. From figure 7, we can conclude that the visual properties of the image have not worsened despite decreasing the resolution twice. Therefore, DCT could significantly reduce the memory size without losing its quality.

Reference

1. The official MATLAB site: https://www.mathworks.com/
2. The text of computer assigments
3. The professor M.R Azimi lecture 11-12 page 6-12
4. The professor M.R Azimi lecture 15-16 page 12-28
5. The official MATLAB Wavelet Toolbox site: https://www.mathworks.com/help/wavelet/index.html