Data Compression and Encoding

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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 and encode the received data. Moreover, the assignment was fined the SNR between the original image and the reconstructed decoded image depending on BPP in encode method. Furthermore, the report presented a comparison between DCT and DWT. All goals were accomplished using MATLAB code [1].

2. Theory

The system presented in Figure 1 has to transform approaches such as DCT and DWT, which replace mapping, quantization, and coder.

Figure 1 The Encoding System

a. DCT approach with encoding

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).

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

The third step was to use the Run-Length [4] encoding method for each i,j bloc to code the image data. The last step was to decode the blocks and inverse it. The received matrix (2) was joined to the full image.

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

b. DWT Approach

The algorithm for DWT transforms is presented in Figure 2 [5].

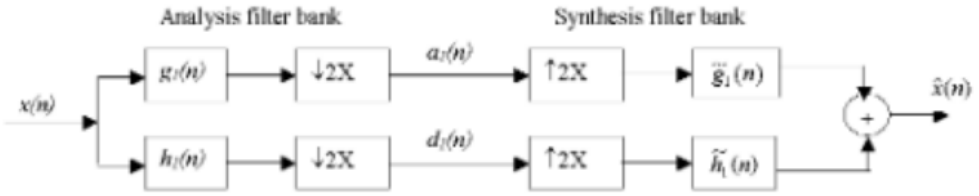


Figure 2 The DWT transforms and reconstructs the image

The h(n,m) and g(n,m) is HP and LP filters respectively. The Huffman encoding method was used for the DWT approach because the coefficient matrix, such as vertical and horizontal, consists of many ones and zeros. That is why using the Run-Length method is not effective.

3. Results and discussion

a. DCT approach

The Matlab code provides an algorithm for DCT transforms for 8x8 and 16x16 blocs with Run-Length encoding. The reconstruction for these two types of the bloc is presented in Figure 3.

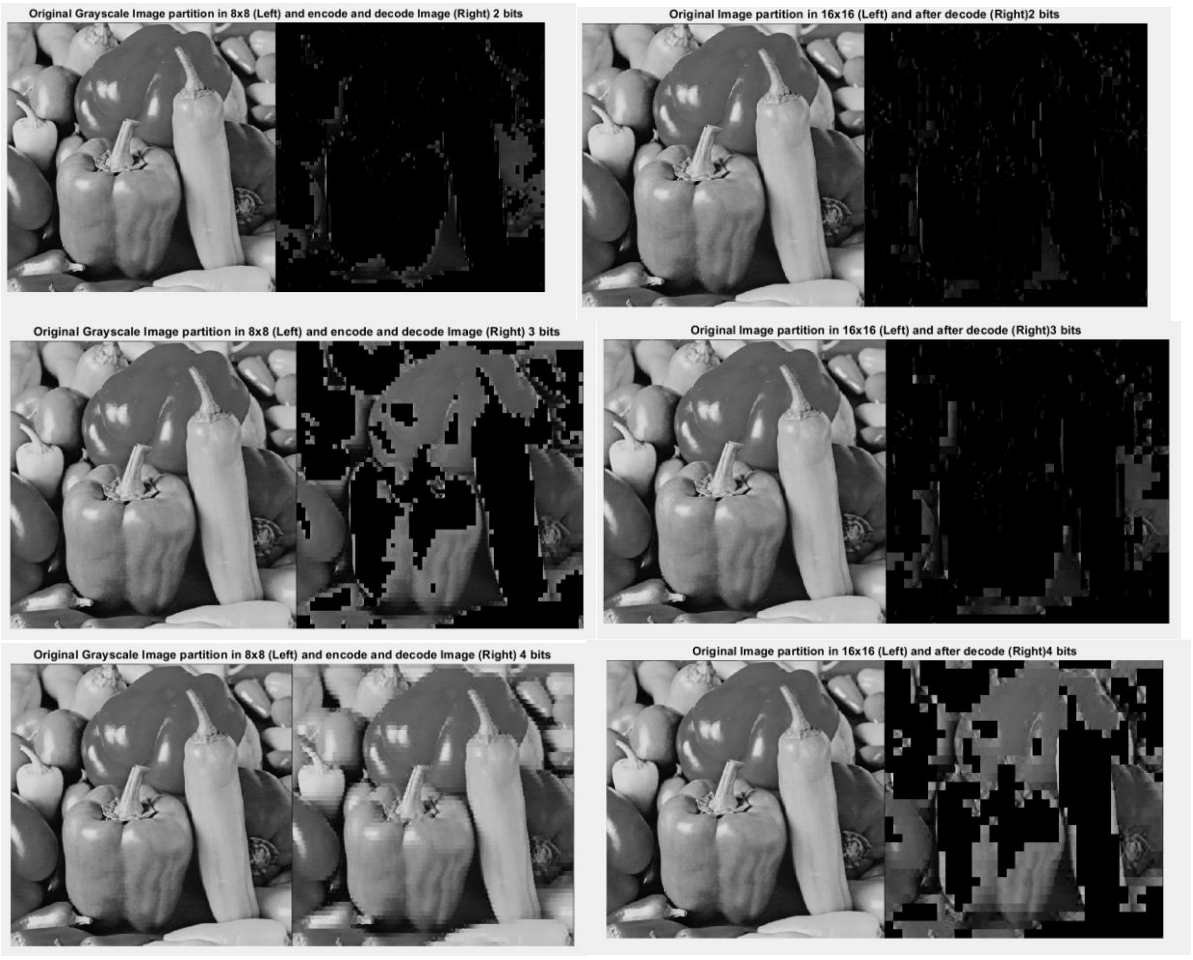


Figure 3 The original and reconstructed image for 8x8 and 16x16 blocs by BBP

The standard features were saved from the original images with more bpp in the encoding method. The reconstructed images are reduced data for each block and code and decode image with save the critical part of the image. This allows the user to compress the images and code and send them without losing the data. The experiments create a plot of dependency graph between the SNR and BPP of the reconstructed and original image, which is presented in Figure 4.

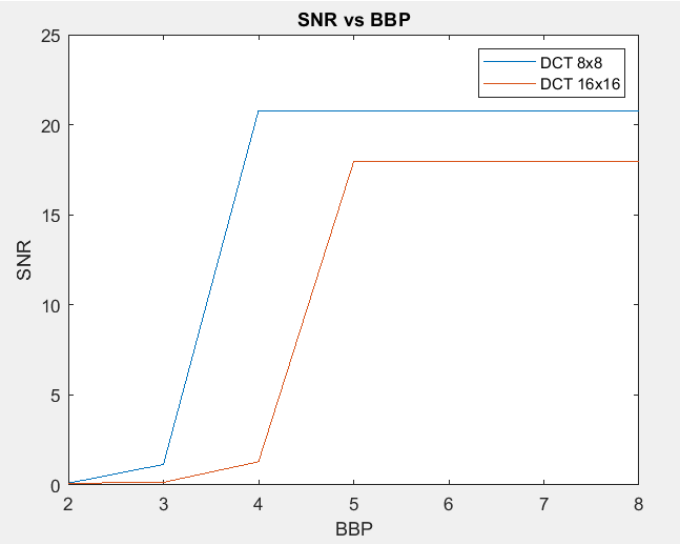
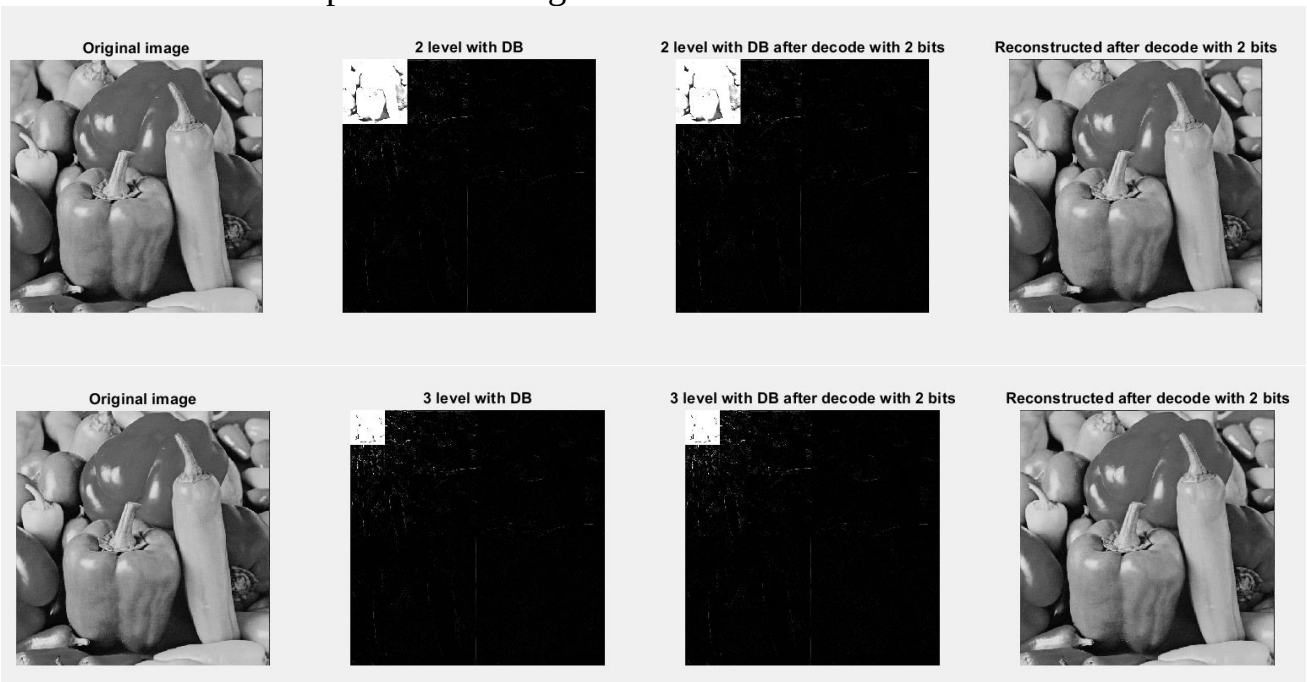


Figure 4 The SNR vs. BPP.

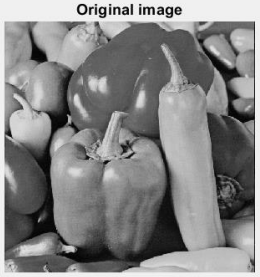
The image could be a perfect reconstruction if the number of bits is enough to code the whole image. Moreover, the 8x8 partition had a better result than the 16x16.

b. DWT Approach

The DWT algorithms use the Wavelet Toolbox. The computer assignments presented two-level and three-level decomposition with different wavelets. The first one is two-level and three-level Daubechies (db4) and Huffman encoding method. The result is presented in Figure 5.



Original image

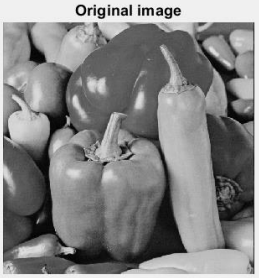


2 level with DB

2 level with DB after decode with 3 bits

Reconstructed after decode with 3 bits

Original image

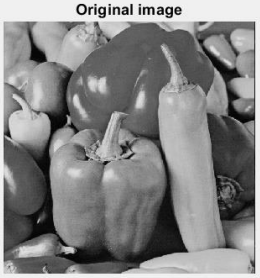


3 level with DB

3 level with DB after decode with 3 bits

Reconstructed after decode with 3 bits

Original image

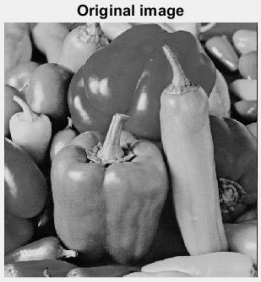


2 level with DB

2 level with DB after decode with 4 bits

Reconstructed after decode with 4 bits

Original image

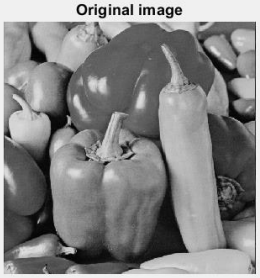


3 level with DB

3 level with DB after decode with 4 bits

Reconstructed after decode with 4 bits

Original image

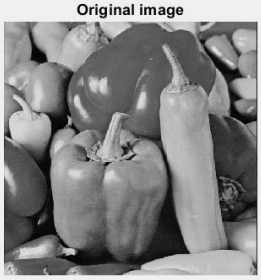


2 level with DB

2 level with DB after decode with 5 bits

Reconstructed after decode with 5 bits

Original image



3 level with DB

3 level with DB after decode with 5 bits

Reconstructed after decode with 5 bits

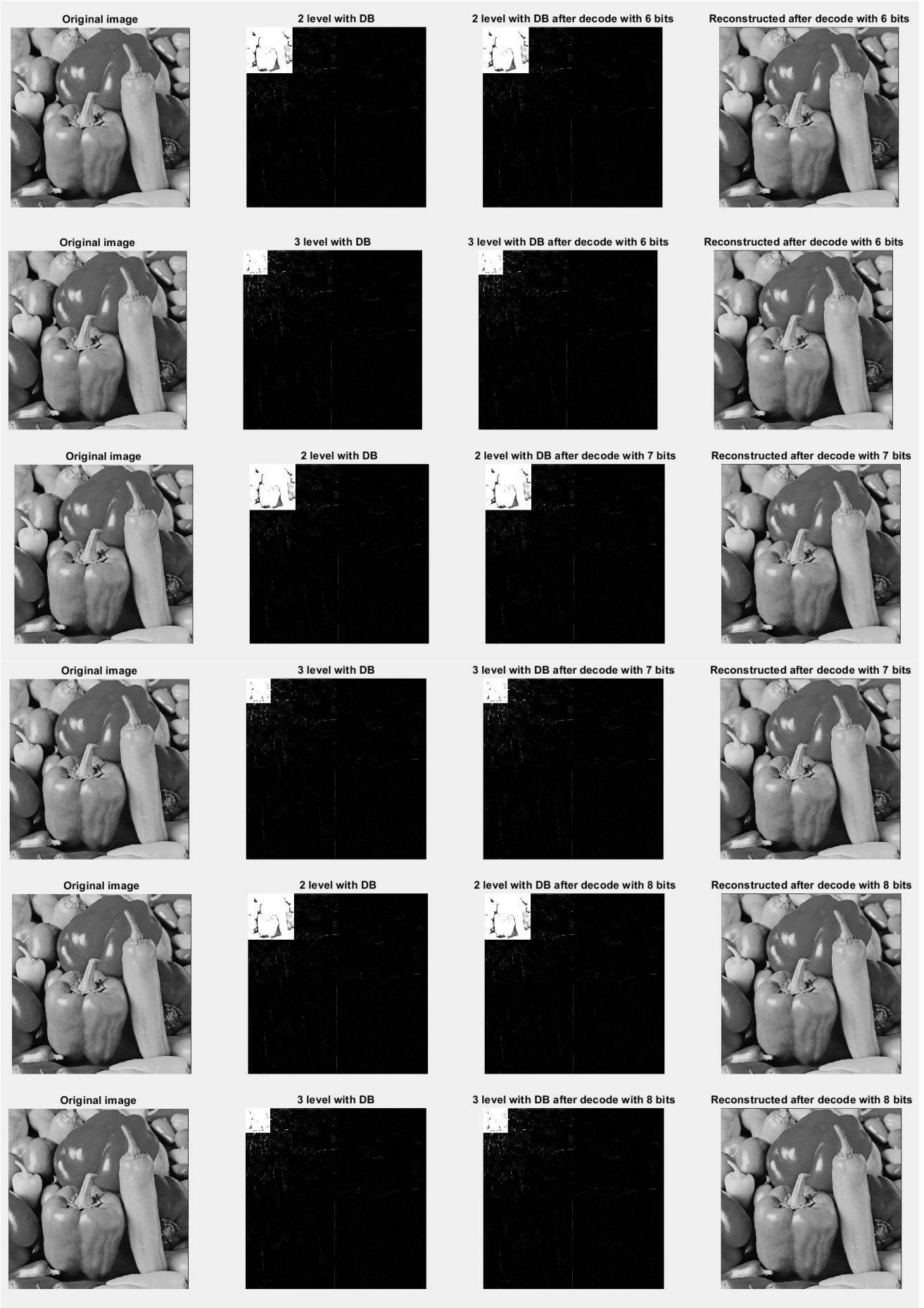
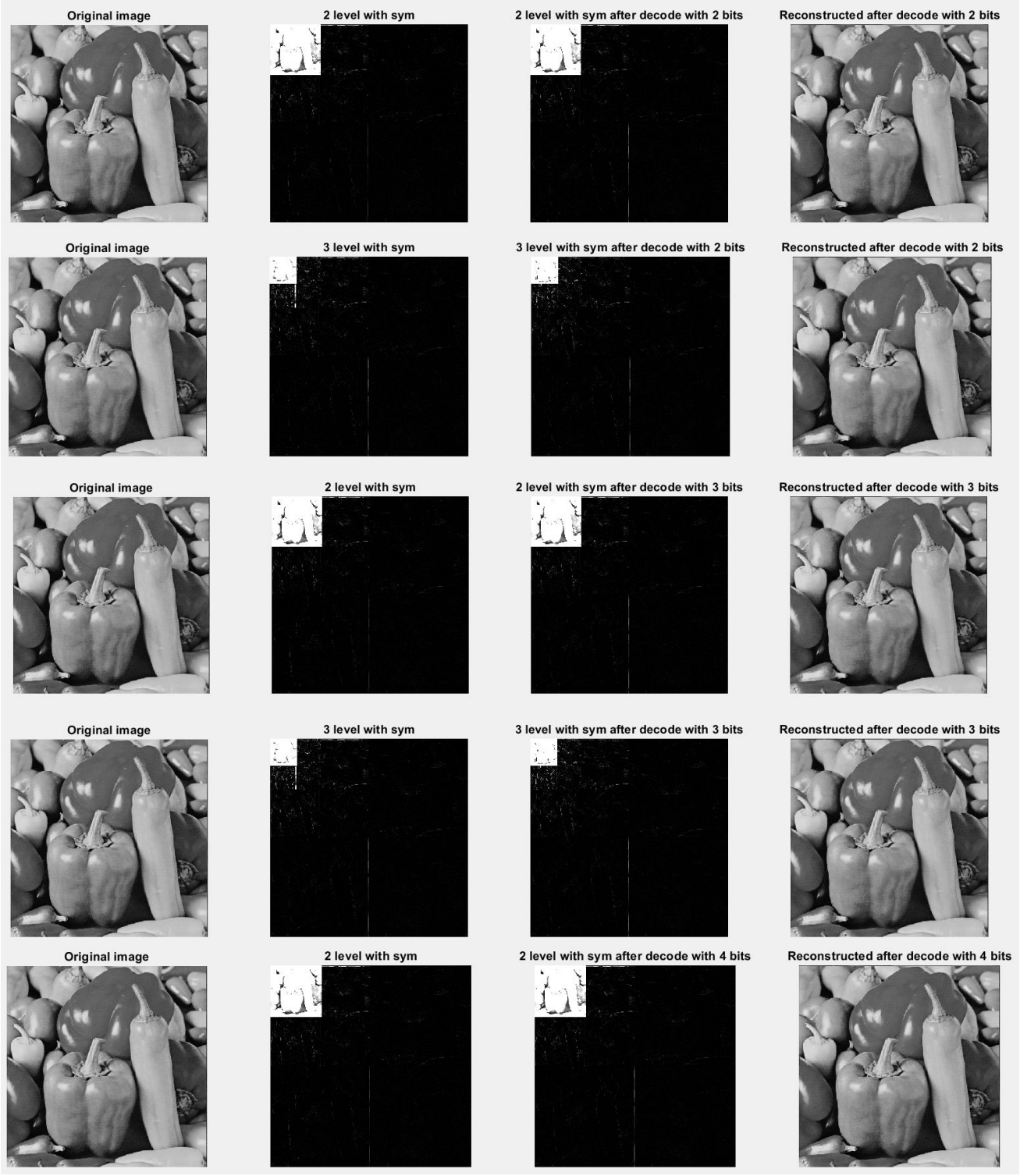
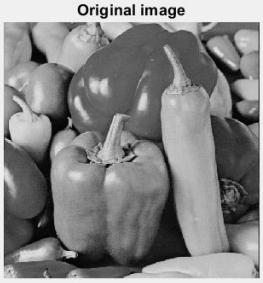


Figure 5 The two-level and three-level decomposition db4 with encoding and decode depends on BPP

The second is a two-level and three-level Symlet (sym) with the same encoding method. The result is presented in Figure 6



Original image

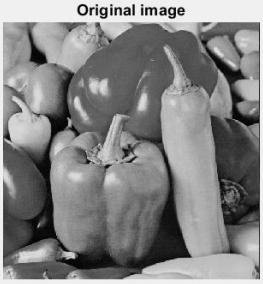


3 level with sym

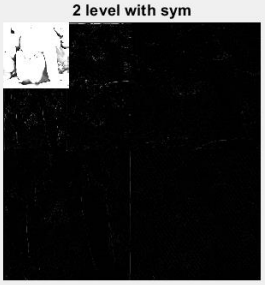
3 level with sym after decode with 4 bits

Reconstructed after decode with 4 bits

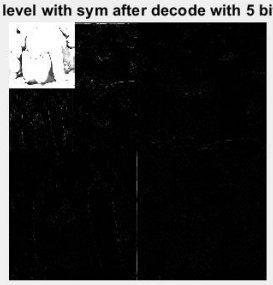
Original image



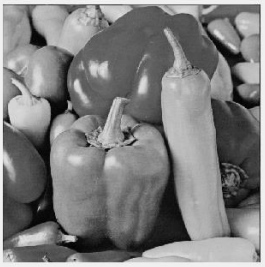
2 level with sym



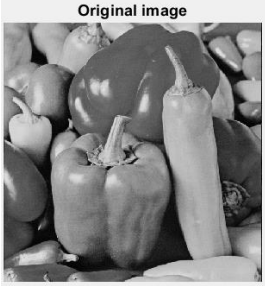
2 level with sym after decode with 5 bits



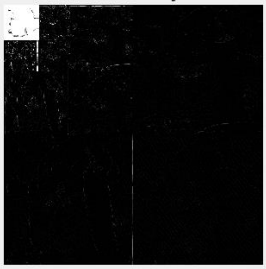
Reconstructed after decode with 5 bits



Original image



3 level with sym



3 level with sym after decode with 5 bits

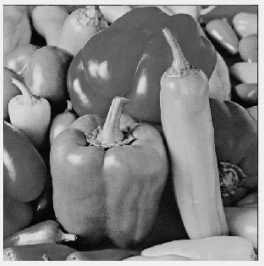
Reconstructed after decode with 5 bits

Original image

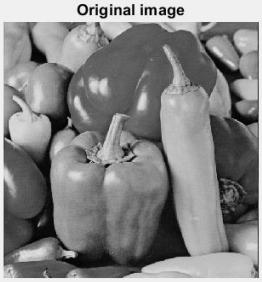
2 level with sym

2 level with sym after decode with 6 bits

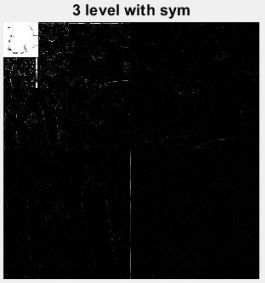
Reconstructed after decode with 6 bits



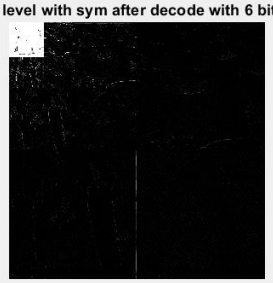
Original image



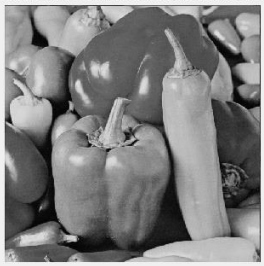
3 level with sym



3 level with sym after decode with 6 bits



Reconstructed after decode with 6 bits



Original image

2 level with sym

2 level with sym after decode with 7 bits

Reconstructed after decode with 7 bits

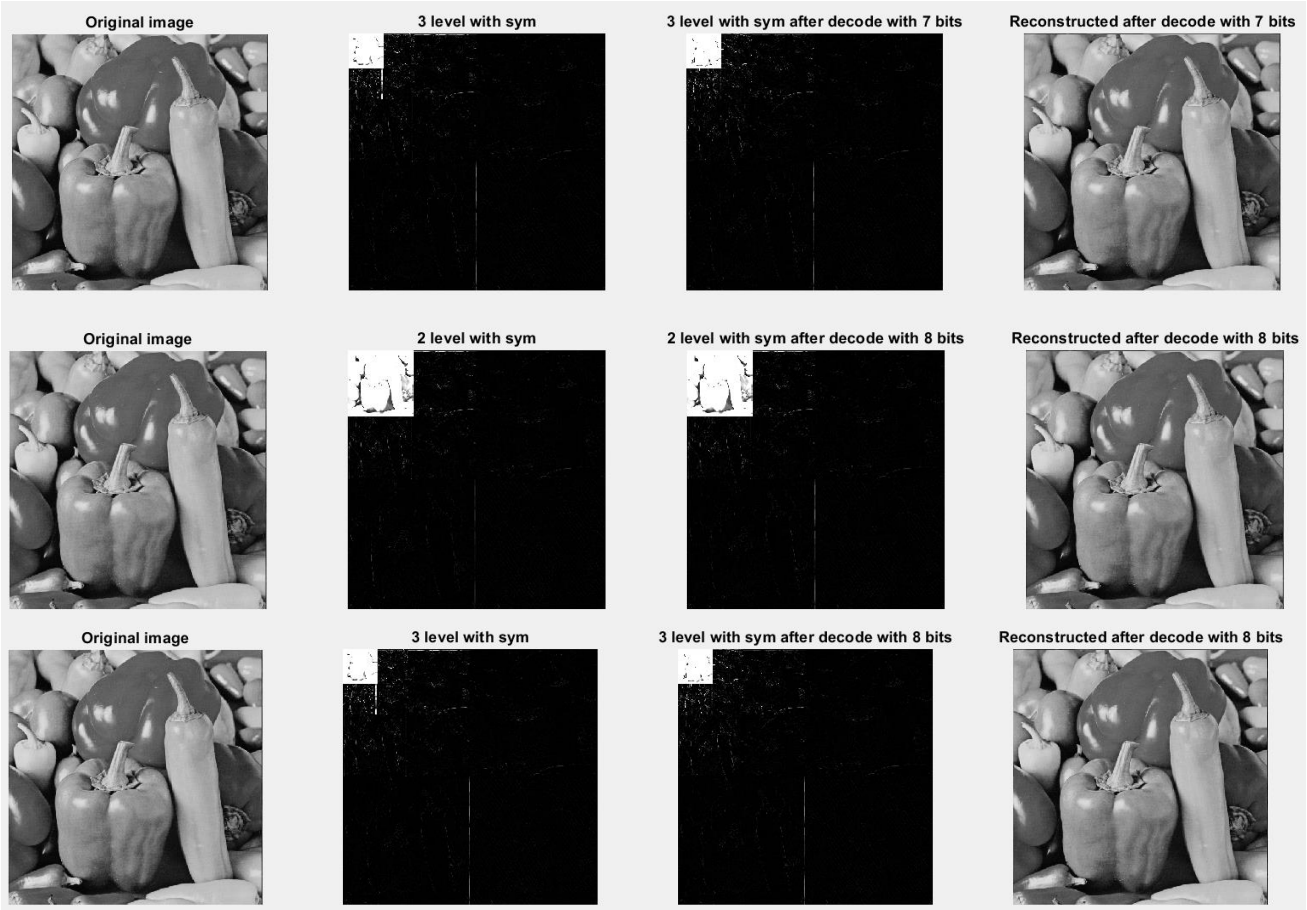


Figure 6 The two-level and three-level decomposition sym with encoding and decode depends on BPP

The experiments create a plot of dependency graph between the SNR and BPP of the reconstructed and original image, which is presented in Figure 7.

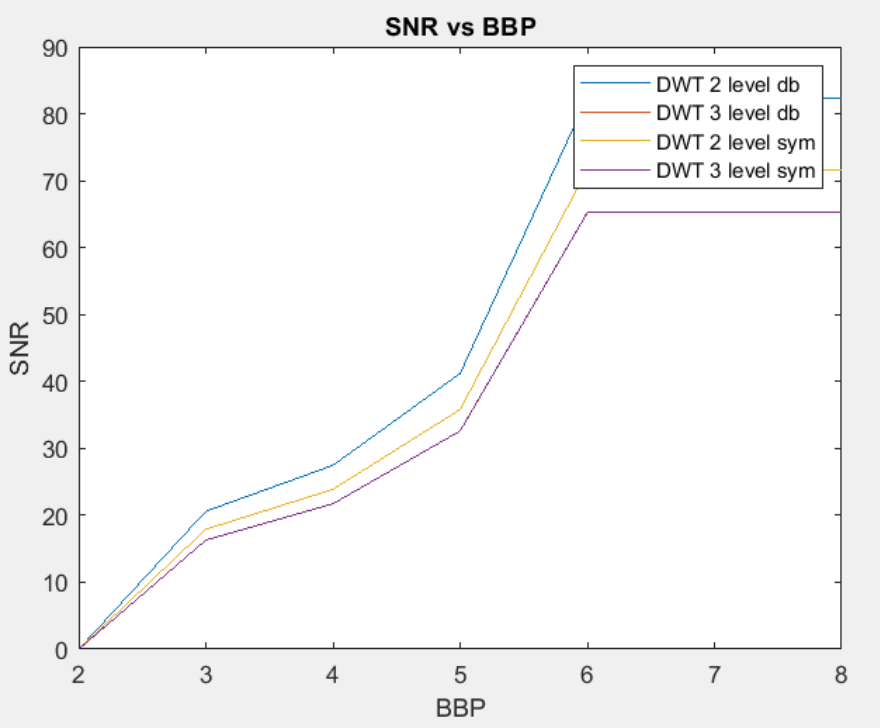


Figure 7 The SNR vs. BPP.

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 2-level decomposition is better after the encoding and decoding process. Therefore, DWT could significantly reduce the memory size without losing its quality. However, the number of images that need to be encoded is more significant than in DCT. Morover, images are more complex, and each is different. This difference forced us to use various encoding methods with suits for this data. Therefore, to achieve high performance, a different encoding method needs to be used, which significantly increases the complexity of the system, unlike the DCT method.

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 25-26 page 6-12
5. The professor M.R Azimi lecture 15-16 page 12-28
6. The official MATLAB Wavelet Toolbox site: https://www.mathworks.com/help/wavelet/index.html