Chapter 3
Proposed Method

3.1 Image Compression

As mentioned in Chapter 2, the design of a wavelet compression system can be divided into three parts: wavelet transform, quantization strategy, and error-free encoding technique. Although one can choose each part at liberty, the portion of the transform is the key step in producing good results. Take DWT for example, the choice of the wavelet filter bank is crucial to the final performance. If the performance of the wavelet filter bank is poor, the quantization and the entropy encoding procedures generally cannot provide adequate compensation to maintain good picture quality. The phenomenon is even more relevant to lossless coding because there is no quantization stage.

To make short of the matter, in wavelet-based image coding, choice of wavelet filter bank is significant. So in our experiments, we focus on selecting the appropriate wavelet filter and do not take the quantizer and the entropy encoder into account.

So in this paper, we achieve compression by neglecting all the wavelet coefficients below a global positive threshold after decomposing the image, and then compression ratio is computed. The compression procedure that we use contains three steps:

1. Decompose:

   Choose a wavelet, and choose a number of decompositions *D*.

   Compute the wavelet decompositions of the image at *D* level.

   Fig. 3-1 shows the decompositions of Lena image using Haar wavelet and four decompositions.

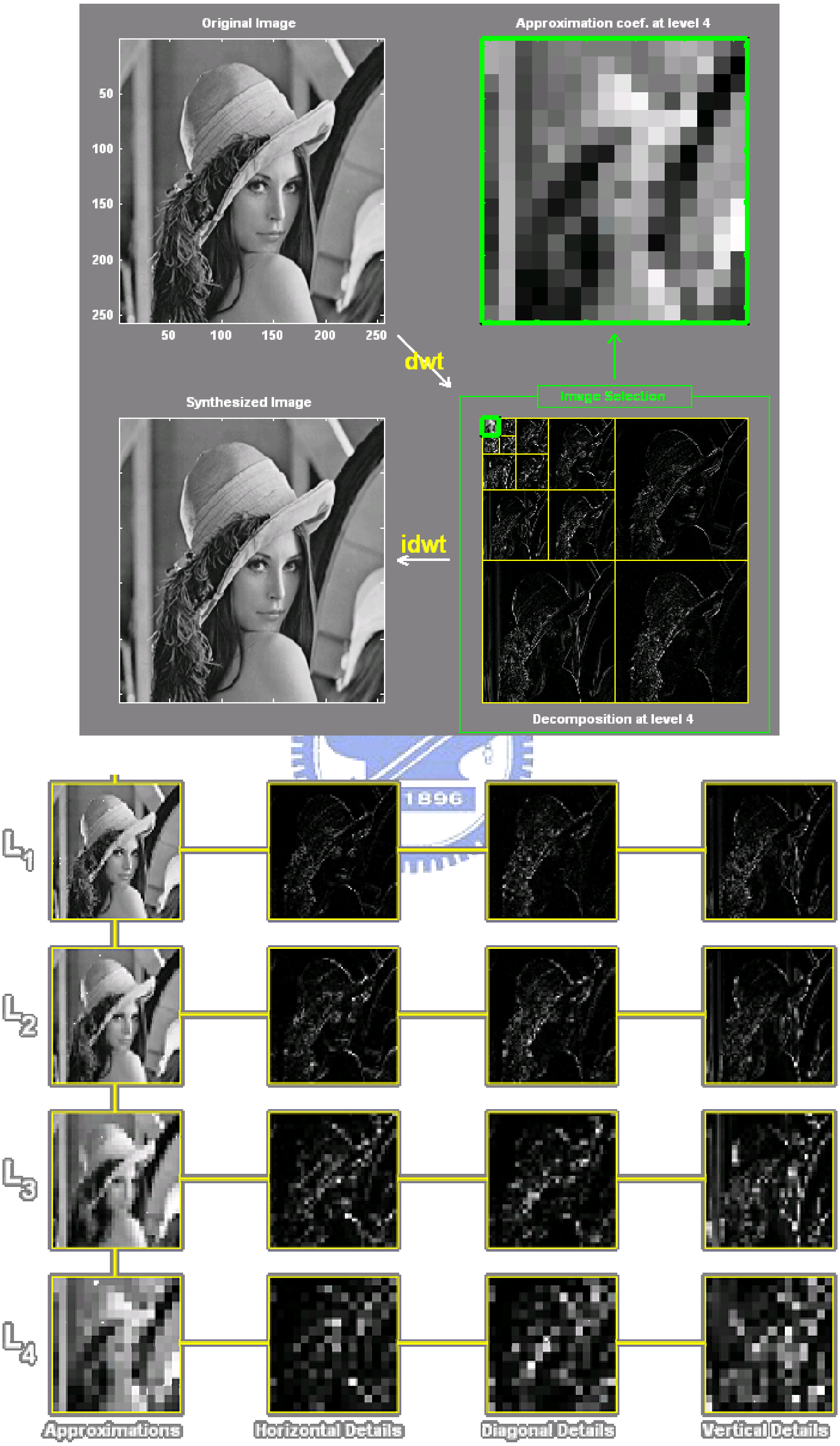

Fig. 3-1. Wavelet decompositions. (a) View mode: square (b) View mode: tree

2. Threshold:

   For each level (from 1 to D), a global threshold is selected and hard thresholding is applied to the detailed coefficients.

   (Another way is to use different thresholds for each level, and also for each decomposition direction: horizontal, vertical, and diagonal. But we do not adopt this way in this paper.)

3. Reconstruct:

   Compute wavelet reconstruction using the original approximation coefficients of level D and the modified detailed coefficients of levels from 1 to D.

3.2 Parameters of Experiments

We do lots of experiments and then make some comparisons. Selection depends on some basic parameters such as choice of wavelet families, filter orders, number of decompositions, compression ratios, and different image contents. There are some relations between each other.

In this paper, four often-used wavelet families are chosen to our experiments. They are Haar Wavelet (HW) family, Daubechies Wavelet (DW) family, Coiflet Wavelet (CW) family, and Biorthogonal Wavelet (BW) family.

HW (DW1), DW, and CW are parameterized by filter order (N), while BW uses filter orders for decomposition (N_d) and reconstruction (N_r). In HW and DW families, we experiment DW1, DW2, DW5, and DW10 with number of decompositions (D) = 2, 3, 4, 5, 6, 8 and 10, respectively. In CW family, we experiment CW2, CW3, CW4, CW5 with number of decompositions = 3, 4, 5 and 6, respectively. And in BW family, BW2.2, BW3.3, BW6.8 with number of decompositions = 3, 5, 6 and 8 are also respectively experimented. In addition, compression ratios of the experiments are 10:1, 30:1, and 50:1.

3.3 Image Contents

In an image compression system, choosing test images for evaluations is a difficult problem. The choice of wavelet function should be adjusted to different image contents in order to get better compression performance. After analyzing and doing lots of comparisons, we can discover which wavelet function is more suitable for a certain image. Also the suitable filter order and suitable number of decompositions can be obtained.

In this paper, we use several 256×256 grayscale images. The images are obtained from USC-SIPI image database [11]. They are Lena, Peppers, Baboon, House, Airplane, Man, Aerial, Grass, Barbara, Boat, Fruits, Goldhill, Straw, Text, and Resolution Chart. Each of the images is shown in Appendix A.

Fig. 3-2 shows the histograms of some types of test images. The histogram of an image can provide many clues to the characters of the image. For example, a narrowly distributed histogram indicates the contrast of this image is low. A bimodal histogram often means that the objects and the background of this image are with different amplitude range. Fig. 3-3 shows another comparison of image contents using some spatial features (such as mean, median, and standard deviation) of each test image.

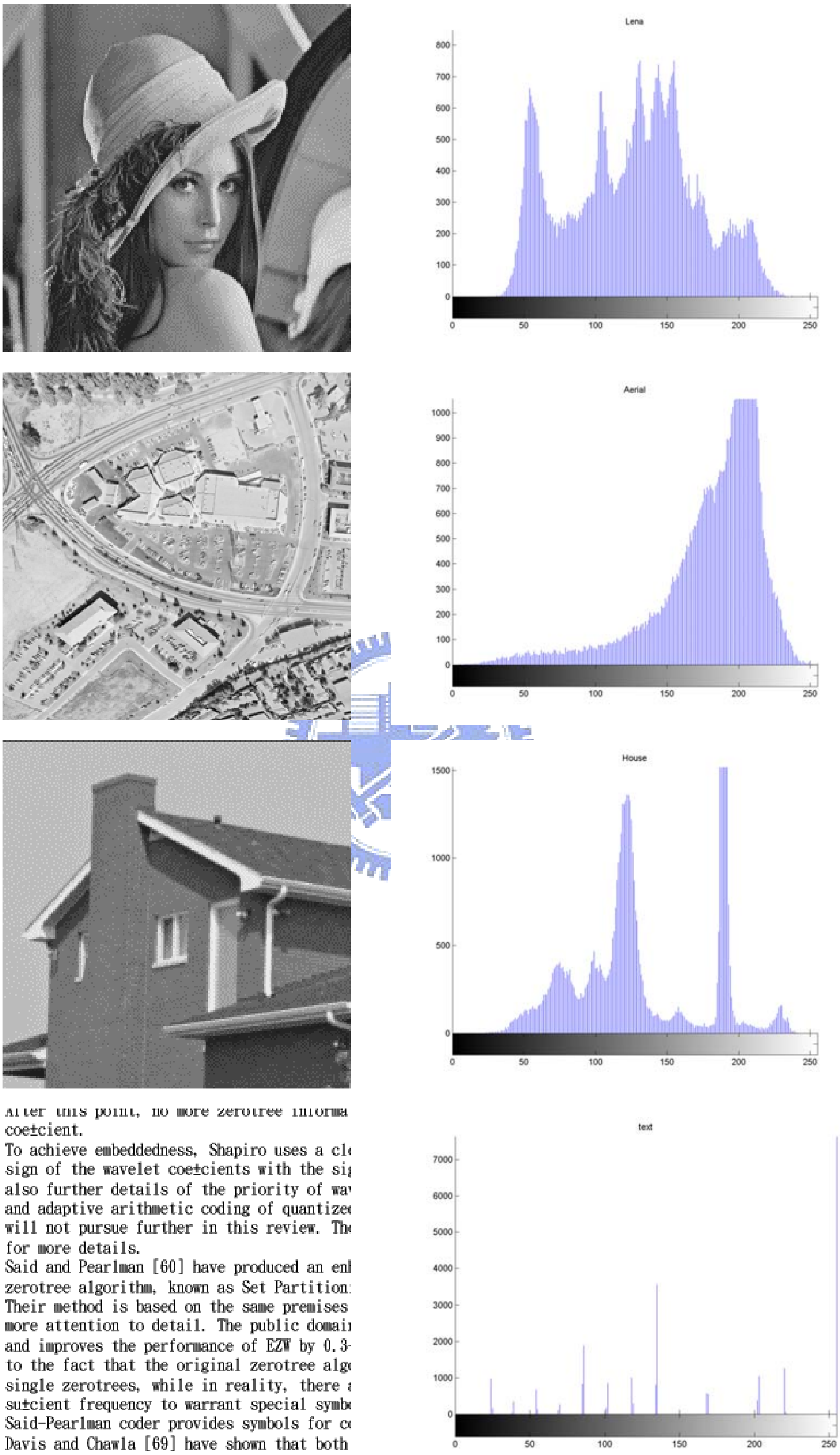

Fig. 3-2. Some test images and their histograms.

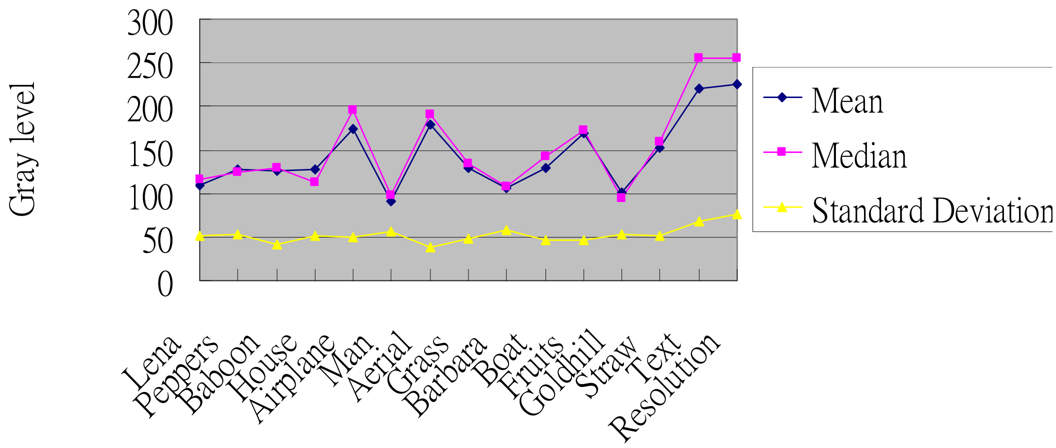

Fig. 3-3. The spatial features of each test image.

The differences of test images can be classified not only by the spatial features mentioned above but also by the frequency contents. On the right side of each image in Appendix A, the distributions of DCT coefficients of the test images are shown, respectively. DCT coefficients are represented by white dots, and the arrows indicate the increase of horizontal and vertical frequency.

Except pure binary text images (Text and Resolution Chart images), by the distributions of DCT coefficients shown in Appendix A, the test images in this paper are roughly distinguished into two categories: moderate spectral activity images and higher spectral activity images. The images of higher spectral activity are Baboon, Aerial, Straw, and Grass images. They contain large number of small details and low spatial redundancy, so are more difficult for a compression system to deal with. On the other way, the images of moderate spectral activity are House, Lena, Fruits, Golhhill, Peppers, Barbara, Airplane, Boat, and Man images. From Fig. 4-2, it can be discovered that higher spectral activity images have lower PSNR values than the moderate ones.