Efficiency of Different Image Compression Algorithms

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Abstract

In this lab report, we explore the the relative efficiency of different types of image compression techniques by comparing the number of Huffman encoding bits used per pixel.

1 Introduction

Transmission of images is an important aspect of the internet, but images require a large number of bits to encode their pixels. In order to transmit images more effectively it is beneficial to use compression techniques which use fewer bits than the original image. In this experiment five compression methods were studied on a representative subset of images. The first method, called waterfall, replaces each pixel value with the difference between its original value and the original value of the pixel above it. The second compression technique, called range reducer, works by simply reducing the total number of colors within the picture to 60 rather than allowing the full 256 brightness range. Wavelet, the third method, takes the average of two consecutive pixels and stores it on the left side of a new array. It then stores half the difference between those same original pixels on the right side of the array. The fourth technique performs the wavelet encoding scheme recursively until there is only one column that is averages, and all the rest are half of the differences. The final method performs recursive wavelet and then the waterfall encoding method to the result. These five methods were tested on four images which highlight different properties of images which could potentially require compression.

The tested images show different levels of contrast between adjacent pixels and different ranges in color. The 8 pixel image is a simple image with only two colors and extreme contrast between adjacent pixels. The Mandril photo is a photo with a wide color range but since it is a real image most adjacent pixels are fairly similar to their neighbors. The noise photo is a photo where each pixel has a random brightness value so there is lots of contrast and a wide range in color. The final image is the gradient which features a wide range of brightness values but has a very progressive change in color as suggested by its name. These four images each have different combinations of color range and adjacent pixel contrast which reveal how each compression algorithm depends on these aspects of photos.

2 Data

Table 1: Range Reducer

Image Name	Huffman Encoding Bits per pixel	Subjective quality of picture
8 pixel	1	High quality
Mandril	5.6431,5.4148,5.7085	High quality
Noise	3.9585	High quality
Gradient	5.8444	High quality
Swan Boat	5.4924,5.3834,5.1312	High quality

Table 2: Waterfall

Image Name	Huffman Encoding Bits per pixel	Subjective quality of picture
8 pixel	1	High quality
Mandrill	6.3578,6.6460,6.6257	High quality
Noise	7.3064	High quality
Gradient	2.4113	High Quality
Swan Boat	6.4279,6.3200,6.3253	High quality

Table 3: Wavelet

Image Name	Huffman Encoding Bits per pixel	Subjective quality of picture
8 pixel	1.25	High quality
Mandril	7.3189,7.3701,7.4789	High quality
Noise	7.0129	High quality
Gradient	5.4869	High quality
Swan Boat	7.3578,7.2371,7.0817	High quality

Table 4: Recursive Wavelet

Image Name	Huffman Encoding Bits per pixel	Subjective quality of picture
8 pixel	2.25	High quality
Mandril	5.4255,5.6627,5.7501	Good quality
Noise	7.2176	High quality
Gradient	2.7693	High quality
Swan Boat	5.5594,5.4005,5.3707	High quality

Table 5: Recursive Wavelet and Waterfall

Image Name	Huffman Encoding Bits per pixel	Subjective quality of picture
8 pixel	1.171875	High quality
Mandril	5.1809,5.51583,5.4746	High quality
Noise	8.3434	High quality
Gradient	1.3951	Not the best
Swan Boat	5.2421,5.1618,5.1831	High quality

Table 6: No Simplification

Image Name	Huffman Encoding Bits per pixel (RGB)	Subjective quality of picture
8 pixel	1	
Mandril	7.6396,7.4088,7.7050	
Noise	4.8138	
Gradient	7.8422	
Swan Boat	7.4840,7.3744,7.1241	

Table 7: Compression Ratios

	Range Reducer	Waterfall	Wavelet	Recursive Wavelet	Waterfall and Wavelet
8 pixel	1	1	1.25	2.25	1.1718
Mandril	0.7369	0.8628	0.9743	0.74	0.71078
Noise	0.8223	1.518	1.4568	1.4994	1.733
Gradient	0.7453	0.9317	0.6996	0.3531	0.1779

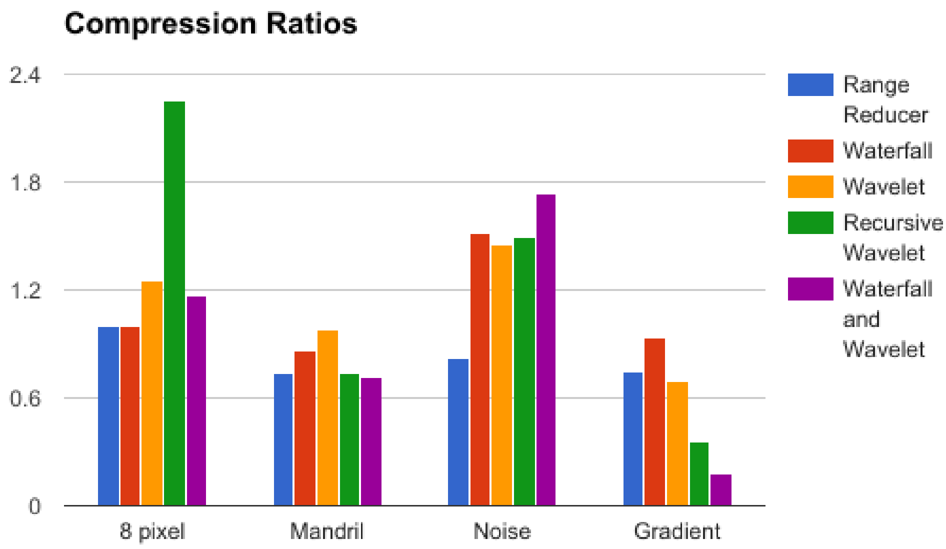

Figure 1: Note: The compression ratio is defined as the number of Huffman encoding bits per pixel of the compressed image divided by the number of Huffman encoding bits per pixel of the original image. Smaller is better.

3 Conclusion

From the compression ratio data above, we can conclude that the Waterfall+Recursive Wavelet technique is the most efficient method for compressing typical images that would be taken with a camera. This is because it is very effective as compressing images with a fairly normal gradient, as can be seen by the how effectively it reduced the gradient image. Unfortunately, the image quality of the decoded gradient picture is noticeably worse.

Range Reducer works well on images with enough variation in color and/or brightness to be compressed effectively. Waterfall compares very well in terms of efficiency with the other methods, however, it is not as effective as the other methods with pictures having large gradients. The recursive wavelet appears to be more effective in larger images (images with a greater number of pixels), and particularly well on pictures with a large gradient. Wavelet is a mediocre technique. It never performs the best, but does perform the worst in pictures with a many colors and abrupt changes in colors (such as the mandrill picture). Recursive wavelet is particularly effective in images with a lot of colors and large gradient (such as mandrill and gradient). Recursive Wavelet performs better than the non-recursive wavelet method in these pictures; however, in small pictures and pictures with extreme/abrupt contrast (such as 8-pixel and Noise), the non-recursive Wavelet method performs better.

We can see that all the tested algorithms other than range reducer depend of the gradients in the images. This is highlighted by the noise and 8 pixel images which both require more bits after compression. Further tests would be useful for images with a greater number of pixels. It is likely that recursive wavelet will be more effective as compared to other methods when the number of pixels needed to reduce is greater. Testing multiple images with a line of color, each in different directions, may prove useful in determining which is most efficient for photos with colors concentrated in the center or the edges. Testing images with very different RGB gradients might provide insight as to which is more efficient for an image with a particularly drastic gradient for one color (but not the others).