Adaptive JPEG Compression for Grayscale Images

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Introduction

Images can account for large amounts of the data collected by satellites [1]. As memory and bandwidth are limited, it is critical that image file size be as low as possible while keeping quality high. Digital signal processors are prevalent in satellites and quickly handle transform functions found in lossy compression, so we determined our goal would be to improve upon JPEG.

Background

Developed by the Joint Photographic Experts Group, JPEG is a lossy compression method for images [2]. JPEG separates an image into blocks and uses a discrete cosine transform, or DCT, to represent the image space in a frequency domain. Lower frequencies contain the core structure of the image, while higher frequencies represent the fine details, in which the human visual system is less sensitive. This is exploited in the quantization of the signal, where high frequencies are divided more than low frequencies, often reducing all but the lowest frequencies to zero. The resulting data is then linearized and entropy encoded, where long runs of zeroes are shortened, reducing the file size. All functions have an inverse to return the compressed image. This process is shown in Figure 1.

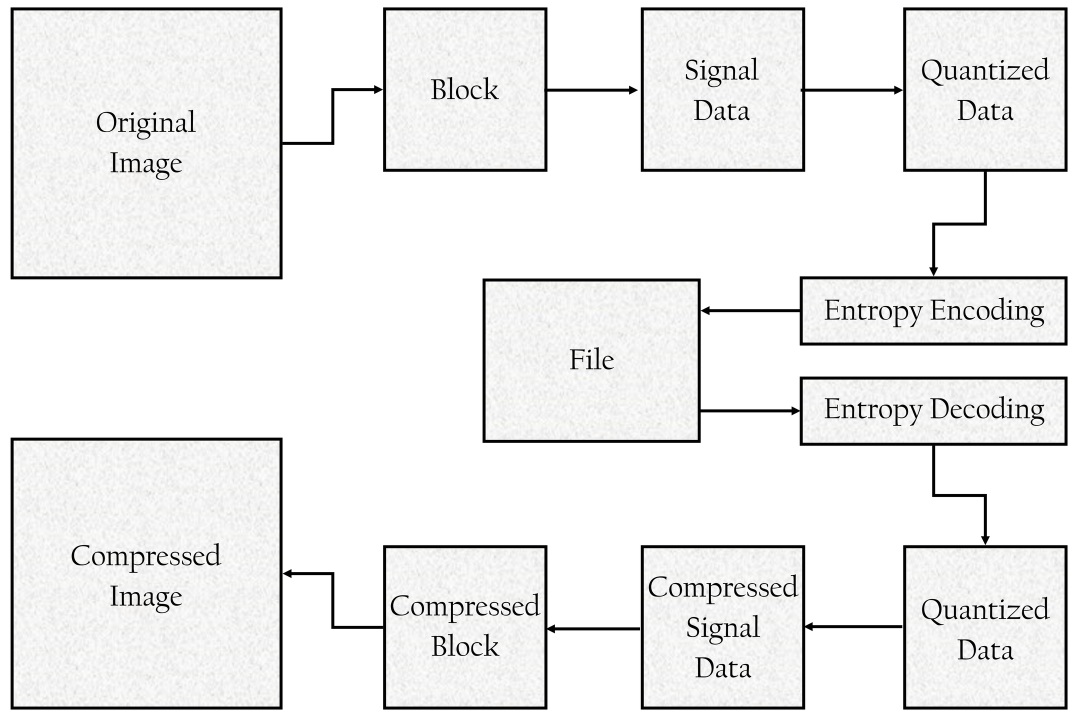

Figure 1. Each block of the image is read, processed, and written to a file. Inverse functions display the image post compression.

Results

Figure 2. Top row from left to right: Original Mandrill, Proposed Method (Set 2), JPEG Method (Set 2). Bottom row from left to right: Original Lena, Proposed Method (Set 2), JPEG Method (Set 2).

Table 1. Proposed method is compared against JPEG. Each set contains different initial parameters for the proposed method. JPEG quality is adjusted for better comparison.

		Set 1					Set 2		
		PSNR (dB)	File Size (Bytes)	dB/byte (x10^4)			PSNR (dB)	File Size (Bytes)	dB/byte (x10^4)
Mandrill	Proposed Method	32.529251	122932	2.646117	Mandrill	Proposed Method	38.167912	158893	2.402114
	JPEG	32.502785	122394	2.655586		JPEG	37.069016	163798	2.263093
Lena	Proposed Method	38.473793	63313	6.07676	Lena	Proposed Method	32.679253	24783	13.18616
	JPEG	38.489368	64116	6.003083		JPEG	32.940453	21756	15.14086
Peppers	Proposed Method	32.099098	23238	13.81319	Peppers	Proposed Method	37.462574	75141	4.985637
	JPEG	32.147724	22634	14.20329		JPEG	37.053524	77355	4.790062
Gold Hill	Proposed Method	30.244574	26882	11.25086	Gold Hill	Proposed Method	37.133190	103170	3.599224
	JPEG	30.346806	26508	11.44817		JPEG	36.751045	105341	3.488769

Results (Continued)

Much of the specific methodology is patent pending/confidential. In this test, both methods have entropy encoding simulated by gzip. Table 1 displays testing results. The superior method was determined by comparing dB/byte values of each method. Figure 2 displays Mandrill, whose results met expectations with light compression, and Lena, whose heavier compression produced unfavorable results.

Conclusions & Future Work

Results thus far are inconclusive. The current adaptive method isn't always superior to JPEG, especially when heavily compressed. Extended knowledge of the human visual system can help guide future optimization [3]. Much of the foundation for future development has been implemented. Color images must ultimately be supported, and proper entropy encoding must be added. Eventually transform code should be ported to a digital signal processor.

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