



Universal Image Quality

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Abstract

We worked on applying an objective comparison of image quality in image compression. This objective measure is the recently published "Image Quality Index" (IQI). We applied the IQI to obtaining objective comparisons of two different state of the art image compression algorithms: the faculty mentor's ASWDR algorithm, the JPEG algorithm, and the JPEG2000 algorithm.

We will also did research on developing an algorithm that incorporates the IQI into an image compression algorithm. Thereby allowing a user to specify a desired quality--based on the objective IQI measure. This preassigned quality value would be superior to the JPEG or JPEG2000 "quality" specifications, which are not well-justified empirically in relation to human visual appraisal of quality. An image compressor incorporating the IQI measure is a significant new development.

IQI Definition

$$Q = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \cdot \frac{2 \bar{x} \bar{y}}{(\bar{x})^2 + (\bar{y})^2} \cdot \frac{2 \sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2}$$

Linear Correlation

Luminance

Contrast

$$\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i, \quad \bar{y} = \frac{1}{N} \sum_{i=1}^N y_i,$$

$$\sigma_x^2 = \frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2, \quad \sigma_y^2 = \frac{1}{N-1} \sum_{i=1}^N (y_i - \bar{y})^2,$$

$$\sigma_{xy} = \frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})(y_i - \bar{y}).$$

Application to Images

It is more appropriate to compare statistical features locally and then combine them for the overall quality.

The IQI accomplishes this using a sliding window of 8x8 pixels. The average window quality from j=1 to the total number of steps, M, is the overall IQI for the image.

$$Q = \frac{1}{M} \sum_{j=1}^M Q_j$$

Comparison

Some previous work of the faculty mentor has shown that ASWDR may be superior, in visual terms, to the JPEG-type algorithms. Using the IQI, we obtained objective confirmation that ASWDR meets or surpasses the quality of the JPEG algorithms in most cases. The following chart shows the comparisons between ASWDR and JPEG2000 using PSNR and IQI evaluations on a suite of test images.

		PSNR		IQI		BEST IQI
		ASWDR	JPEG	ASWDR	JPEG	
	1:8	38.87	39.22	0.76	0.76	TIE
	1:16	34.20	34.54	0.68	0.68	TIE
	1:32	30.80	30.95	0.59	0.59	TIE
	1:100	26.55	26.31	0.44	0.43	ASWDR
	1:8	40.00	40.27	0.85	0.83	ASWDR
	1:16	36.72	37.12	0.77	0.75	ASWDR
	1:32	33.72	33.87	0.68	0.67	ASWDR
	1:100	28.82	28.59	0.51	0.51	TIE
	1:8	36.32	36.51	0.88	0.88	TIE
	1:16	32.93	33.15	0.79	0.80	JPEG
	1:32	30.39	30.36	0.69	0.67	ASWDR
	1:100	27.13	27.12	0.50	0.49	ASWDR
	1:8	36.04	37.07	0.87	0.87	TIE
	1:16	30.99	32.05	0.79	0.79	TIE
	1:32	27.14	28.18	0.69	0.69	TIE
	1:100	23.65	23.78	0.50	0.48	ASWDR

The following two images are the results of compressing "Barb" at a ratio of 1:100. ASWDR receives a higher IQI and noticeably retains key features of the original image better, for instance the facial features.



Q = 0.48



Q = 0.50

Implementation

We implemented a method that uses the IQI applied to the transform of an image to estimate the quality of the compressed image. The method uses the same sliding window approach for localized feature comparison and also weights each portion of the transform differently. The sliding window size is smaller for the transform, using a width of 4 for level 0 and 2 for subsequent levels. The method is defined below.

C = column count, R = row count
Finding the weighted qualities of the sublevels:

$$Q_{sub} = \sum_{n=0}^{levels-1} (Q_{nV} + Q_{nH} + Q_{nD}) \cdot 2^n$$

Total amounts of "data" for the quantized transform as well as the "data" in the top level image of the quantized transform.

$$E_{tot} = \sum_{x=0}^C \sum_{y=0}^R [T_Q(x, y)], \quad E_{img} = \sum_{x=0}^{C_{img}} \sum_{y=0}^{R_{img}} [T_Q(x, y)],$$

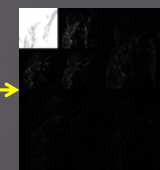
$$C_{img} = C/2^{levels}, \quad R_{img} = R/2^{levels}$$

Current quality estimate is given by the formula:

$$Q = \left(\frac{Q_{sub}}{\sum_{x=0}^{C_{img}} \sum_{y=0}^{R_{img}} 3 \cdot 2^n} \cdot \frac{E_{tot} - E_{img}}{E_{tot}} \right) + \left(Q_{img} \cdot \frac{E_{img}}{E_{tot}} \right)$$

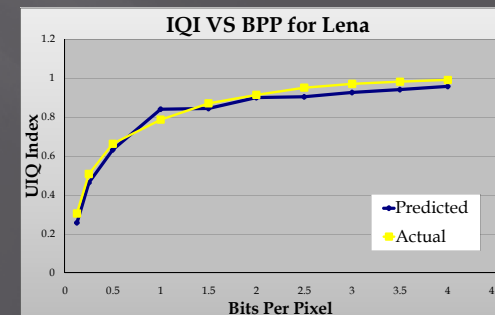


Original



Transform

Below is an example compression of test image Lena. The yellow curve represents the actual IQI of the compression, and the blue curve represents the predicted quality given by applying the above method to the transform.



Lena Compression Using: 2 levels, Daub 9/7 Wavelet, ASWDR Compression, Arithmetic Encoding

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