Fidelity Criteria

When lossy compression techniques are employed, the decompressed image will not be identical to the original image. In such cases , we can define fidelity criteria that measure the difference between this two images. Two general classes of criteria are used:*(1)* objective fidelity criteria and *(2)*subjective fidelity criteria. <u>Subjective:</u> based on human observers. <u>Objective:</u> mathematically defined criteria.

A good example for (1) objective fidelity criteria is root-mean square *(RMS)* error between an input and output image For any value of *x* , and *y* , the error *e(x,y)* can be defined as :

$$e(x,y) = f'(x,y) - f(x,y)$$

The total error between two images is: $\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left[f'(x,y) - f(x,y)\right]$

The root mean square error, e_{rms} *or* (RMS) is : $e_{rms} = \left[\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left[f'(x,y) - f(x,y)\right]^2\right]^{\frac{1}{2}}$

or

$$e_{rms} = \sqrt{\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(\hat{f}(x,y) - f(x,y))^2}$$

- Mean-square signal-to-noise ratio (SNR) : A closely related objective fidelity criterion is the mean square signal to noise ratio of the compressed-decompressed image.

$$SNR_{ms} = \frac{\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (\hat{f}(x,y))^2}{\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (\hat{f}(x,y) - f(x,y))^2}$$

$$SNR_{peak} = 10 \log_{10} \frac{(L-1)^2}{\frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left[\hat{f}(x,y) - f(x,y)\right]^2}$$

Where L is number of gray levels.

A larger number of SNR_{peak} implies a better image.

Subjective Fidelity Criteria

These criteria measure image quality by the subjective evaluations of a human observer. This can be done by showing a decompressed image to a group of viewers and averaging their evaluations. The evaluations may be made using an absolute rating scale, for example {Excellent Fine, Passable, Marginal, Inferior, and Unusable}.

Value	Rating	Description
1	Excellent	An image of extremely high quality as good as you could desire.
2	Fine	An image of high quality providing enjoyable viewing. Interference is somewhat objectionable.
3	Passable	An image of acceptable quality. Interference is somewhat objectionable.
4	Marginal	An image of poor quality that you wish could be improved. Interference is somewhat objectionable.
5	Inferior	A very poor image but can be viewed. Objectionable interference is definitely present.
6	Unusable	An image so bad that it cannot be viewed

Compression Ratio

$$Compression\ Ratio = \frac{Uncompressed\ File\ Size}{Compressed\ File\ Size} = C_R$$

<u>Ex.</u> : Image 256 * 256 pixels, 256 level grayscale can be compressed file size 6554 byte.

Original Image Size = 256 * 256 (pixels) * 1(byte/pixel)

= 65536 bytes

$$compression\ Ratio = \frac{65536}{6554} \approx 10$$

Bits per pixel (*bpp*): denote the number of bits required to represent an image pixel

$$Bits\ per\ Pixel = \frac{Number\ of\ Bits}{Number\ of\ Pixels}$$

$$bpp = \frac{\text{Number of Bits}}{\text{Number of Pixels}} = \frac{8(\text{Number of Bytes})}{N \times N}$$

<u>Ex.</u> : Image 256 * 256 pixels, 256 level grayscale can be compressed file size 6554 byte.

Original Image Size = 256 * 256 (pixels) * 1(byte/pixel)

= 65536 bytes

Compressed file = 6554 (bytes) * 8 (bits/pixel)

= 52432 bits

$$Bits\ per\ Pixel = \frac{52432}{65536} \approx 0.8$$