IMAGE COMPRESSION

Image compression addresses the problem of reducing the amount of data required to represent a digital image. The underlying basis of reduction process is the removal of redundant data. Data redundancy is a central issue in digital image compression, Image compression refers to the process of reducing the amount of data required to represent a given quantity of information.

~~If n_1 and n_2 denote~~

~~Data redundancy is a central issue in digital image compression~~

Data redundancy is not an ~~abstrst~~ abstract concept but a mathematically quantifiable entity. If n_1 and n_2 denote the number of information-carrying units in two data sets that represent the same information. The relative data redundancy R_D of the first data set (~~the~~ ~~chart~~ characterized by n_1) can be defined as

$$R_D = 1 - \frac{1}{C_R} \quad \text{---} (1)$$

Where C_R = Compression ratio.

$$C_R = \frac{n_1}{n_2} \quad \text{---} (2)$$

Senerios.

* For $n_2 = n_2$. $C_R = 1$ $R_D = 0$ Indicating that (relative to the second data set) the first represent of the information contains no redundant data.
* When $n_2 << n_1$. $C_R \to \infty$ $R_D \approx 1$ ~~which implies that~~ Implying significant compression and highly redundant data.
* When $n_2 >> n_1$ $C_R \to 0$ $R_D = \infty$ Indicating the second data set contains much more data than the original representation.

Three basic data redundancies exist in digital Image Compression. They are: Coding redundancy, Interpixel redundancy and psycho visual redundancy. Data Compression is achieved when one or more of the redundancies are reduced and eliminated.

(i) Code Redundancy → An Image is said to contain Code redundancy, if the graylevel of the Image are Coded in such that it used more coded symbols than absoultely necessary to represent each gray level.

Lets assume that a discrete variable r_K in the Interval [0, 1] represents the gray levels of an Image and that each r_K occurs with probability $P_r(r_K)$

$$P_r(r_K) = \frac{n_K}{n} \quad K = 0, 1, 2 \ldots, L-1 \qquad (3)$$

Where L is the number of gray levels, n_K is the number of times that the kth gray level appers in the Image. and n is the total number of pixels in the Image. If the number of bits used to represent each value of r_K is $L(r_K)$ then the average number of bits required to represent each pixel is

$$L_{avg} = \sum_{K=0}^{L-1} L(r_K) P_r(r_K) \qquad (4)$$

~~That is~~ L_{avg} = the average lenght of the Code words assigned to various values. Thus the total number of bits required to Code an M × N Images = MNLavg.

E.g. Table 1 shows the graylevel distribution of a 8-level Image. If a natural 3-bit binary code [code 1 and $L(r_K)$] is used to represent the 8 Possible graylevel $L_{avg} = 3$ If Code 2 is deployed Calculate (i) Average lenght of the Code (ii) Compression ratio (iii) redundancy.

Scanned by CamScanner

r_k	$P(r_k)$	Code 1	$L_1(r_k)$	Code 2	$L_2(r_k)$
$r_0 = 0$	0.19	000	3	11	2
$r_1 = 1/7$	0.25	001	3	01	2
$r_2 = 2/7$	0.21	0011	3	10	2
$r_3 = 3/7$	0.16	100	3	001	3
$r_4 = 4/7$	0.08	101	3	0001	4
$r_5 = 5/7$	0.06	101	3	00001	5
$r_6 = 6/7$	0.03	110		000001	6
$r_7 = 1$	0.02	111	3	000000	6

Solution.

(i) from the formular stated above.

$$L_{avg} = \sum_{k=0}^{7} L_2(r_k) P_r(r_k)$$

$$= 2(0.19) + 2(0.25) + 2(0.21) + 3(0.16) + 4(0.08) + 5(0.06) + 6(0.03) + 6(0.02)$$

$= 2.7$ bit.

(ii) Compression ratio. $C_R = 3/2.7 = 1.11$

(iii) $R_D = 1 - \frac{1}{1.11} = 0.099$

In the preceding example, assigning few bits to the more probable gray levels than the less probable one achieve variable data compression. The process is commonly referred to as variable length coding. ~~If the gray levels of an image are coded in a way that use more code symbols than absolutely ne~~

2) Interpixel redundancy → it is defined as failure to identify and utilize data relationships. If a pixel can be reasonably predicted from its neighboring pixels the image is said to contain interpixel redundancy. The autocorrelation ~~concepts~~ coefficient of image can be computed ~~using the following~~ along the line of an image using the following equation.
~~Equation~~

$$\gamma(\Delta n) = \frac{A(\Delta n)}{A(0)} \quad \text{---} \quad (5)$$

where

$$A(\Delta n) = \frac{1}{N-\Delta n} \sum_{y=0}^{N-1-\Delta n} f(x,y)\, f(x,y+\Delta n) \quad \text{--} \quad (6)$$

~~Where~~ $A(\Delta n)$ is the scaling factor which accounts ~~for~~ the varying number of terms the arise for each integer value of Δn. It is important to note that Δn must be strictly less the N while the variable x is the the number of pixel on a line. While the variable x is the co-ordinate of the line used in the computation.

When $\Delta n = 1$ γ is 0.9922 and 0.9928 for images (1) it indicates that adjacent pixel of images are highly correlated. 2) Values of each pixel is very predictable on values of its neighboring pixel. (3) Each pixel carries low information content.

(3) Psychovisual Redundancy: This occurs when certain information of less relative importance than other information required for normal visual processing are present in an image. This less important information can be eliminated without significantly impairing the quality of image perception.

Improved grayscale quantization is used to ~~redu~~ eliminate Psycho visual redundancy. It is typical of a large group of quantization procedures that operate directly on the gray level of an image to be compressed. The entail ~~false~~ decrease in the image's spatial or gray scale resolution, ~~thus resulting~~

Image Compression models

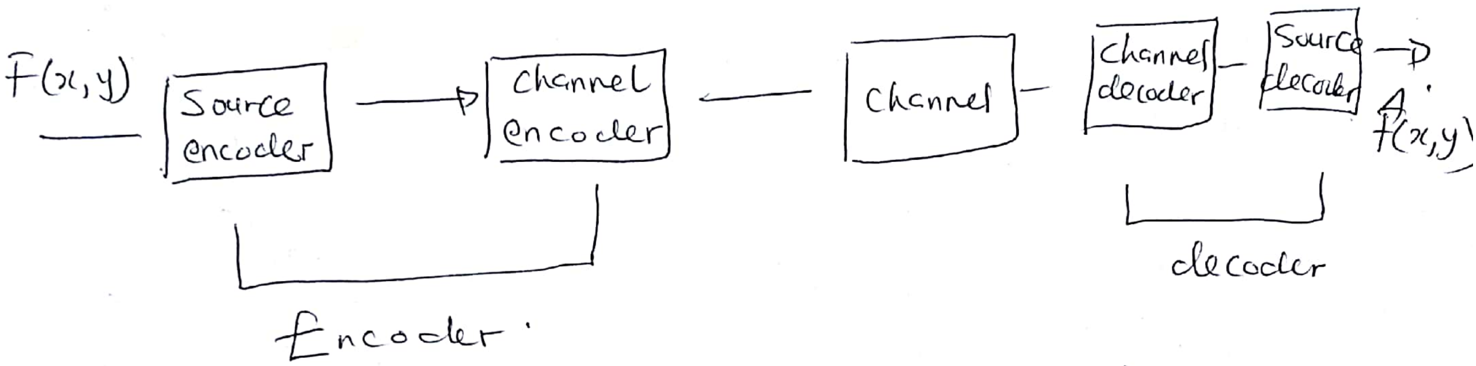


Fig: A General Compression System Model.

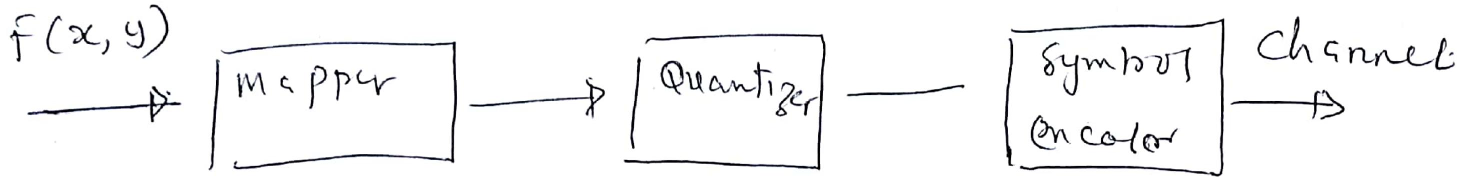
A shown above the compression system consist of two distinction blocks: an encoder and a decoder. An Input Image F(x,y) is feeds into the encoder, which creates a system of symbols as input symbol from the input ~~symbol~~ data. After transmission over the channel, the encoded representation is fed to the decoder, where the reconstructed output image $\hat{f}(x,y)$ is generated. In generally, $\hat{f}(x,y)$ ~~can be~~ may or may not be an exact replica of $f(x,y)$. If its the system is error free or information preserving if is ~~is~~ not some level of distortion is present in the reconstructed image.

The encoder is made up of a source encoder which removes input redundances, and a channel encoder which increases the noise immunity of the source encoder's output, ~~If the channel b/t the encoder and decoder is~~ noise ~~free (not prone to error)~~.

~~The Sc~~

(A) Source Encoder and Decoder.

- The Source encoder is responsible for reducing or eliminating redundancy (coding interpixel or physchovisual)) in the input image.

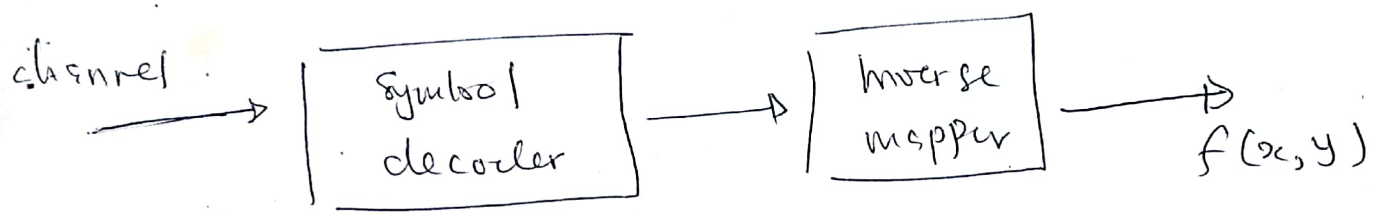


i) Source encoder.

As shown in the figure above, the mapper transforms the input data into a (usually non visual) format design to to reduce interpixel redundancy in the input image. This operation is ~~Irreversible~~ ~~Irreversible~~ reversible and may or may not reduce directly the amount of data required to represent the image.

. The quantizer block reduces the accuracy of the mapper's output in accordance with some pre established fidelity criterion. This stage reduces physovisual redundancy of the input image. This process is irreversible. Thus it must be ommitted if it is error free.

The symbol coder creaters a fixed or variable length code to represent the quantizer output and maps output in accordance with the code. It assigns the shortest code words to most frequently occuring output values and thus reduces code redundancy.



Source decoder.

The figure above shows the source decoder, it contains only two components: a symbol decoder and an inverse mapper. The blocks perform in reverse order the inverse operation of the source encoder's symbol encoder block.

(B) The channel Encoder and Decoder.

- They are designed to reduce the impact of channel noise by inserting a controlled form of redundancy into the source encoded data. The most common encoding technique was designed by Hamming R.W. it is based on appending enough bits to the data to be encoded to ensure that some minimum number of bits must change btw valid codewords.