①

unit - IV

Image Compression

Image Compression.

Fundamentals

* Redundancy

Relative data redundancy RD.

$$R_D = 1 - 1/C_R.$$

$C_R \rightarrow$ Compression ratio $\Rightarrow C_R = \frac{n_1}{n_2}$

$n_2 = n_1 \Rightarrow C_R = 1 \Rightarrow R_D = 0$

$n_2 << n_1, C_R \rightarrow \infty \; R_D \rightarrow 1$

$n_2 >> n_1, C_R \rightarrow 0 \; \& \; R_D \rightarrow -\infty$

* Types of Redundancy.

1) Coding redundancy.
2) Interpixel redundancy → Spatial redundancy, geometric redundancy & Interframe ". (mapping) / temporal "
3) Psychovisual " → .

* 3 Can be identified and exploited.

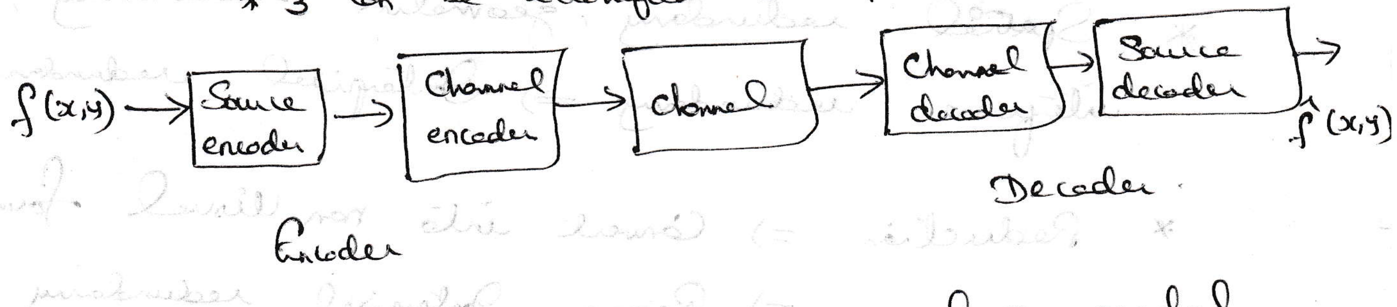


fig ①: General Compression System model.

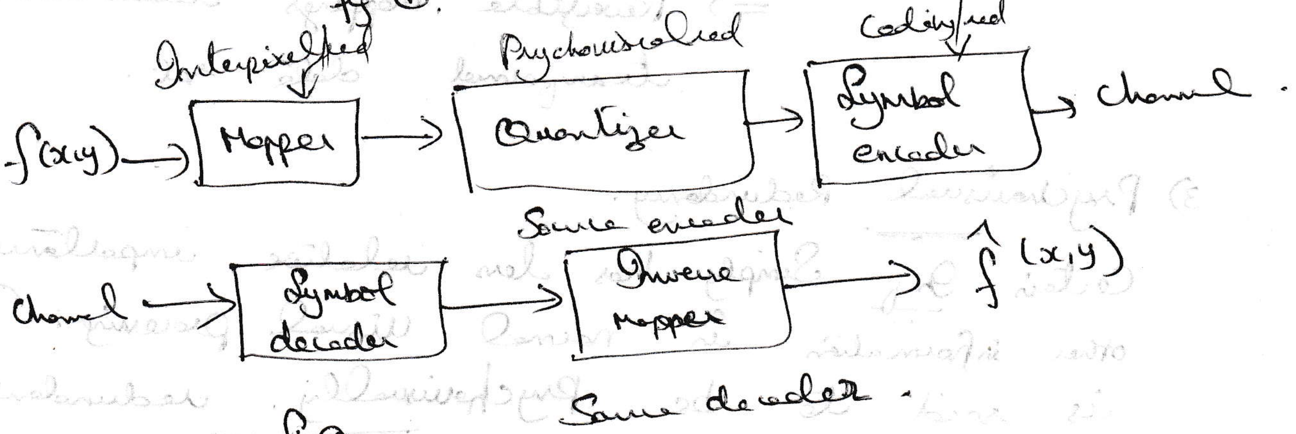


fig ②:

1) Coding redundancy.

* Assigning fewer bits to more probable gray levels than to the less probable ones achieves data Compression ⇒ Variable length coding.

* If the gray levels of an image are coded in a way that uses more code symbols than absolutely necessary to represent each gray level ⇒ Coding redundancy.

2) Interpixel Redundancy :-

* Value of any given pixel can be predicted from the value of its neighbours, Img carried by individual pixels relatively small. * Much of the visual contribution of a single pixel to an image is redundant, It could have been guessed on the basis of value of its neighbours ⇒

* Spatial redundancy, geometric redundancy and interframe redundancy ⇒ Interpixel redundancies/Temporal

* Reduction ⇒ Convert into non visual format.

⇒ Remove Interpixel redundancy ⇒ mappings

⇒ Reversible mappings reconstructed from transformed data set.

3) Psychovisual Redundancy.

Certain Img simply has less relative importance than other information in normal visual processing. This Img is said to be Psychovisually redundant.

* Human perception of the Inf of in image ⇒ Does not involve quantitative analysis of every pixel value in the image.

* General, Observer searches for distinguishing features such as edges (or) textural regions and mentally combines them into recognizable groupings.

* Unlike coding and interpixel redundancy, Psychovisual redundancy is associated with real (or) quantifiable visual information.

* Its elimination is possible only because the Inf itself is not essential for normal visual processing.

* Since the elimination ⇒ **Loss** of quantitative Inf ⇒ Quantization.

* Quantization ⇒ Mapping of a broad range of I/p values to a limited no of o/p values.

* It is an irreversible operation (Visual Inf is lost), ⇒ Quantization results in lossy data comp.

Image Compression Models.

Source Encoder.

* Reducing (or) eliminating coding redundancy.
* Interpixel (or) Psychovisual.

i) Mapper.

* Transforms I/p data into a (nonvisual) format designed to reduce interpixel redundancies in I/p image.

* Operation is reversible ⇒ may or may not reduce directly amount of data required to represent the image.

* Run length coding -> Example

ii) Quantizer

* reduces accuracy of mappers o/p in accordance with preestablished fidelity criterion.

* It reduces Psychovisual redundancies of the I/p Image.

* operation is irreversible.

* It is omitted ⇒ Error free Compression is achieved.

iii) Symbol encoder.

* It creates a fixed (or) VLC to represent Quantizer o/p.

* It reduces coding redundancy.

Source decoder

* Symbol decoder & Inverse mapper ⟹ performs reversible operation

* Quantization results in irreversible inf loss, an Inverse Quantizer block is not included in this.

Channel Encoder & Decoder

* Hamming code used.

Compression
- ① ↓ Error free (Lossless)
- ② ↓ Error (Lossy)

Elements of Inf Theory.

* Meaning of Information

$$\boxed{I(E) = \log \frac{1}{P(E)} = -\log P(E)}$$

↓

Self Inf of an event.

I Error Free Compression (Lossless compression)

Appln ⟹ Archival of medical (or) business documents

⟹ Satellite imagery.

* It reduces Inter pixel redundancies & Coding redundancies.

Types:-

1) Variable length coding → VLC
   - → Huffman coding
   - → Arithmetic coding
2) Lempel - Ziv - welch (LZW) coding
3) Bit - plane coding
   - → Bit plane decomposition.
   - → Constant area coding
   - → 1D RLC.
   - → 2D RLC.
   - → Contour tracing and coding.
4) Lossless predictive coding

II Lossy Compression :-

1) Lossy predictive coding → DM / → DPCM [optimal predictors / optimal Quantization
2) Transform coding → Transform Selection
   - Subimage Size Selection
   - Bit allocation → Zonal coding implementation / → Threshold coding implementation
3) Wavelet coding → Wavelet Selection
   - Decomposition Selection
   - Quantizer design.

Image Compression Standards:

1) Binary image Compression Standards → 1D Compression / → 2D Compression
2) Continuous Tone Still image Compression Stds → JPEG / → JPEG 2000
3) Video Compression Standards → DPCM/DCT
   → MPEG/MPEG4

Lossless Compression Method.

1) Variable length coding (VLC) :-

contd

3) Coding the individual elements within all blocks identically.
4) Adding special shift-up and shift-down symbols to identify each block.

Arithmetic Coding

- It generates non block codes.

- one to one correspondence between Source Symbols and code words does not exist.

- An Entire sequence of source symbols is assigned a single arithmetic code word. The code word itself defines an interval of real numbers between 0 and 1.

- No of Symbols in the msg ↑, Interval used to rep it becomes smaller & no of Inf units used to rep the Interval becomes larger.

- Each Symbol of msg reduces the size of the Interval in accordance with its prob of occurrence.

- Entire half of the open Interval [0,1). → Starting Boundary

- Three decimal digits are used to represent five-Symbol message.

Adv

Easy to Implement a system with multiple arithmetic codes. once the computational machinery to implement one arithmetic code is developed all that is needed to set up multiple

LZW Coding - [Lempel Ziv Welch]

- The technique called LZW coding assigns fixed length code words to Variable length sequences of Source Symbols but requires no a priori knowledge of the probability of occurrence of the symbols to be encoded.

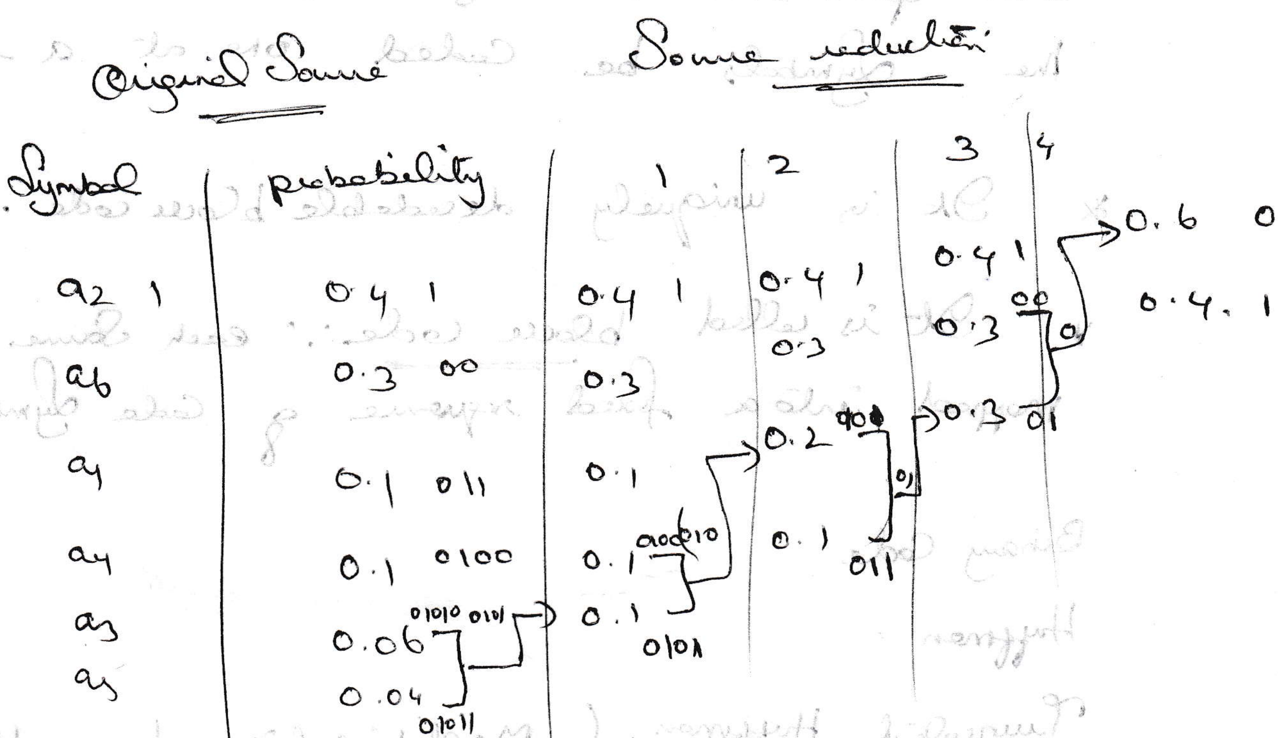
- (GIF), (TIFF) & (PDF).

Error free Compression :- [* Reduce coding redundancy is Simplest approach].

Variable length coding.

* Coding redundancy normally present in any natural binary coding of the grey levels in an image.

* Most popular technique → Huffman.



$$\eta = \frac{\text{Entropy } (H)}{\text{Average No of bits in codeword } (\bar{L})}$$

Redundancy (γ) = 1 − code efficiency

= $1-\eta$.

$$H = P_1 \log_2 (1/P_1) + P_2 \log_2 (1/P_2) + \cdots$$

$$L_{avg} = P_1 (\text{codeword})_1 + P_2 (\text{codeword})_2 + \cdots$$

H, L_{avg} ⟹ units is bits/Symbol.

L_{avg} = 2.2 bits/symbol.

Centropy = 2.14 bits/symbol.

Huffman Code efficiency is 0.973 = 97.3%.

Redundancy = 0.026 ⇒ 2.6%.

* It creates the optimal code for a set of symbols and probabilities subject to the constraint that the symbols be coded one at a time.

* It is uniquely decodable block code.

* It is called block code ∵ each source symbol is mapped into a fixed sequence of code symbols.

Binary Code.

Huffman.

Truncated Huffman. (Modification of basic Huffman Coding Strategy – truncated Huffman Coding). → prefix code.

B2 - Code. → II, near optimal

Binary Shift. VLC. → obeys power law of the form. $P(a_j) = j^{-\beta}$

Huffman Shift. → 2 Inf bits are used per continuation bits.

→ Shift Codes ⇒ A Shift code is generated by

1) arranging the source symbols so that their probabili are monotonically decreasing.

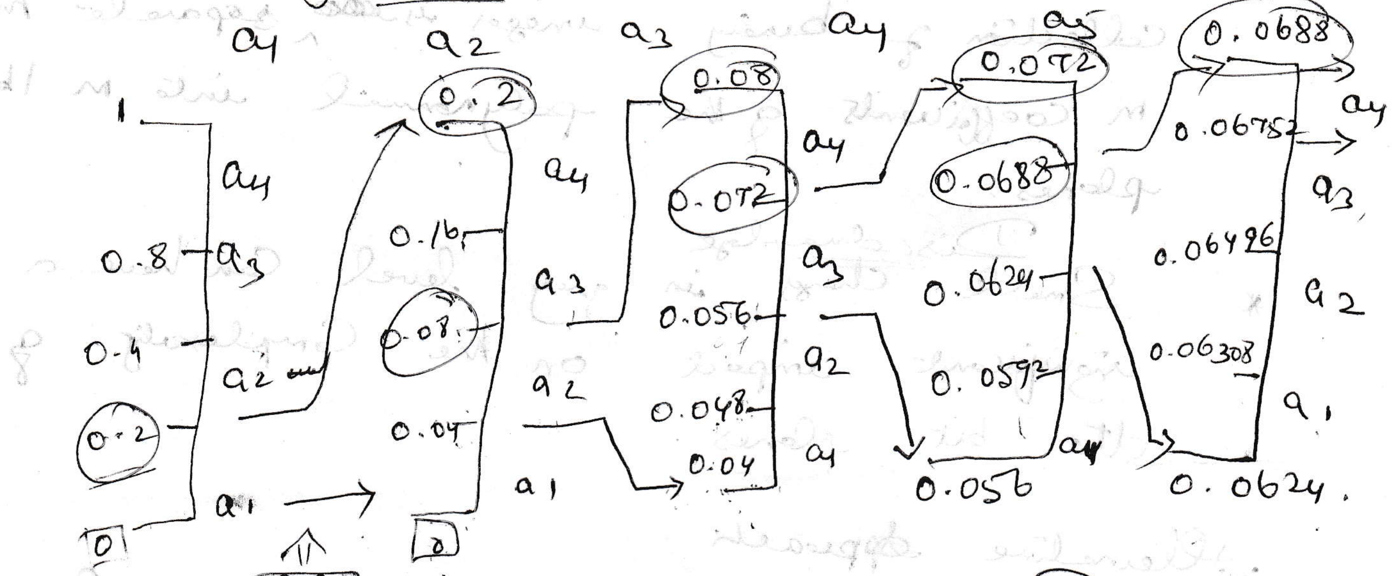
2) Dividing the total no of symbols into symbol blocks of equal size.

Contd in previous page

Arithmetic Coding

* Here a five symbol sequence (or) message $a_1 a_2 a_3 a_4 a_5$ from a 4 Symbol source is coded. At the Start of the coding process → Entire half open Interval [0,1).

Encoding Sequence →



$\frac{1}{5} \Rightarrow 0.2$ $\boxed{\frac{0.2}{5}}$

Arithmetic Coding Procedure.

Source Symbol	Probability	Initial Subinterval
a_1	0.2	[0.0, 0.2)
a_2	0.2	[0.2, 0.4)
a_3	0.4	[0.4, 0.8)
a_4	0.2	[0.8, 1.0)

* 3 decimal digits are used to five Symbol message.
* This translates into 3/5 (or) 0.6 decimal bits/symbol and Compares favorably with the entropy of the Same.
* rounding Strategy needed for this

Bit plane Coding:-

* It reduces Interpixel redundancy.

* Decomposing a multilevel image into a series of binary images and Compressing each binary image via one of several well known binary Compression methods.

* A simple method of decomposing the image into collection of binary images is ~~into~~ to separate the m coefficients of the polynomial into m 1bit planes.

Disadvantage

* Small changes in grey level can have a significant impact on the Complexity of the bit planes.

Alternative Approach

* Represent the image by an m-bit Grey Code.

* The m bit Grey code $g_{m-1} \dots g_2 g_1 g_0$ that corresponds to polynomial ① can be computed from

$$a_{m-1}2^{m-1} + a_{m-2}2^{m-2} + a_{m-3}2^{m-3} + \dots a_1 2^1 + a_0 2^0 \quad ①$$

$$g_i = a_i \oplus a_{i+1}, \quad 0 \le i \le m-2$$

$$g_{m-1} = a_{m-1}$$

* It has the unique property that successive code words differ in only one bit position.

* Small changes in grey level are less likely to

* when the gray level 127 and 128 are adjacent for instance, only 7th bit plane will contain a 0 to 1 transition, ∴ the Gray codes that correspond to 127 and 128 are 11000000 and 01000000, respectively.

Constant area Coding [CAC].

* A simple but effective method of Compressing a binary image (or) bit plane is to used special code words to identify large areas of Contiguous 1's or 0's.

* CAC ⟹ Image divided into blocks of size m×n pixels ⟹ All white, all black (or) mixed intensity.

* Most probable (or) frequently occuring category is then assigned the 1 bit code word 0 & the other 2 categories are assigned the 2 bit codes 10 & 11.

* Compression → 1 bit or 2 bit code word.
→ Mixed intensity category is used as a prefix ⟹ followed by mn bit pattern of the block.

* Solid white areas as 0 & all other blocks by a 1 followed by the bit pattern of the block.
This approach ⟹ white block Skipping (WBS).

* Effective method of modification ⟹ Code Solid white lines as 0's and all other lines with a 1 followed by the normal WBS Code sequence.

* Iterative approach => For 2D blocks, a solid white image is coded as 0 and all other images are divided into subblocks that are assigned a prefix as a 0 & all other images are divided into subblocks followed by a 0 => Solid white.

RLC

1D RLC.

* Effective alternative to CAC represent each row of an image (or) bit plane by a sequence of lengths that describe successive runs of black & white pixels => RLC => facsimile (FAX) Coding.

* Value of a run are i) To specify value of first run of each row
  ii) To assume that each row begins with a white run, whose run length may in fact be Zero.

Entropy of black run length = H_0.

" " white " " = H_1.

Approximate RL entropy of the image is $\boxed{H_{RL} = \frac{H_0 + H_1}{L_0 + L_1}}$

where L_0 & L_1 denote the average values of black⓪ & white run lengths respectively.

* It provides an average no of bits / pixel required to code the run lengths in a binary image using a VLC.

2D Run length coding :-

* Relative address coding (RAC) ⟶ Based on the principle of tracking the binary transitions that begin & end each black & white run.

* It requires adoption of a convention for determining run values.

* In addition, imaginary transitions at the start & end of each line, as well as an imaginary starting line

Contour tracing and coding :-

* Relative address coding ⇒ Intensity transitions that make up the contours in a binary image.

* Represent each contour by a set of boundary points or by a direct contour tracing.

* Yet ⟶ predictive differential Quantizing (PDQ)

⇒ Demonstrates both approaches.

⇒ Scan line oriented contour tracing procedure.

* The front & back contours of each object of an image are traced simultaneously to generate a sequence of pairs (Δ', Δ'').

Δ' => Diff between the Starting Co-ordinates of the front Contours on adjacent lines

Δ'' => Diff between the front to back contour lengths

Diff => Start of new contours (the new start message) and end of old contours (the merge message) represent each object.

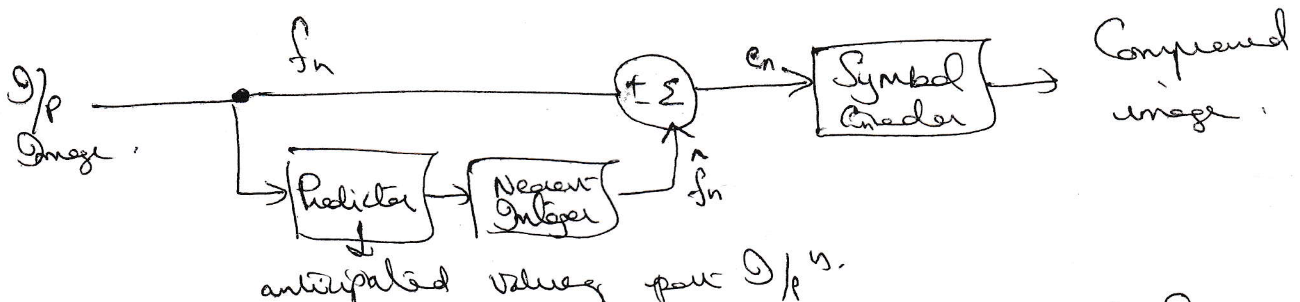
Δ'' => Diff between back contour Co-ordinates of adjacent lines denoted Δ''' => Double delta coding (DDC).

Lossless predictive coding

* It does not require decomposition of an image into a collection of bit planes.

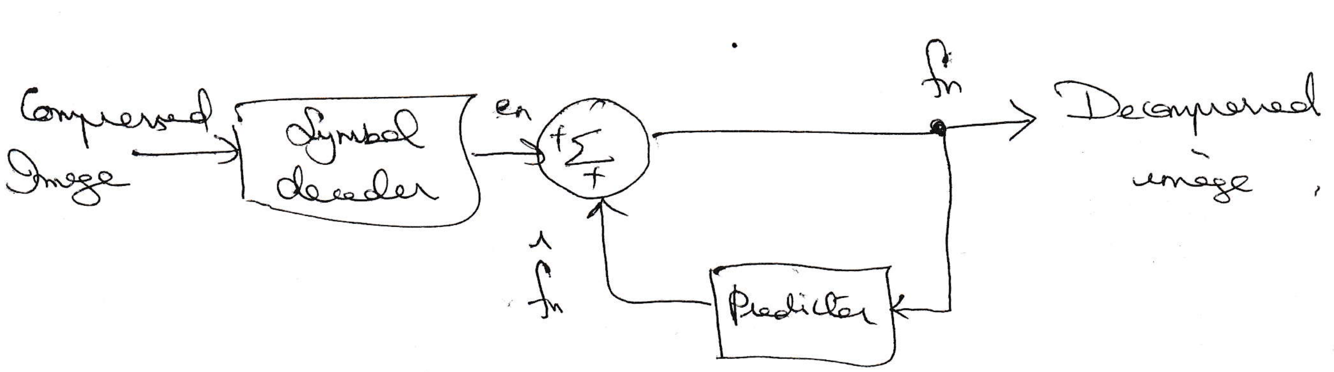
* It is based on eliminating the Interpixel redundancies of closely spaced pixels by extracting & coding only new information in each pixel.

* New Info of a pixel is defined as diff between actual & predicted value of that pixel.



Lossless predictive coding model

a) encoder



prediction error:

$$e_n = f_n - \hat{f}_n \qquad ①$$

$$f_n = e_n + \hat{f}_n \qquad ②$$

$$\hat{f}_n = \text{round}\left[\sum_{i=1}^{m} \alpha_i f_{n-i}\right] \quad \text{—} ③$$

$$\hat{f}_n(x,y) = \text{round}\left[\sum_{i=1}^{m} \alpha_i f(x, y-i)\right] \text{—} ④$$

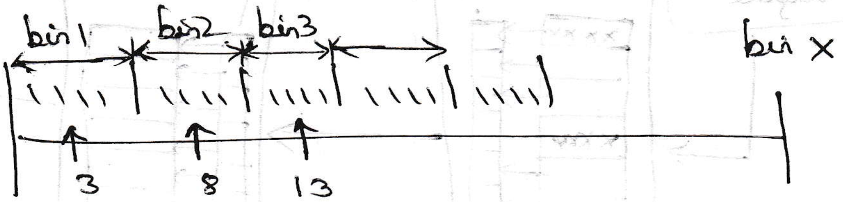
④ cannot be evaluated for the first m pixels of each line ⟹ Huffman code.

1 predictor ⟹ previous pixel predictor.

∆ corresponding predictive coding procedure, referred to as Differential coding ~~E~~ (or) Previous pixel coding.

Vector Quantization

- It is a popular technique for image Compression.
- Consider a no of bins as shown in Fig ⓐ.



Example for vector Quantization

- For each bin => an average value (or) reference value
average values for the bins 1,2,3 are 3,8,13 etc.
- Grouping => Data has 1 to 20 no's grouped to 4 groups.
- mapping of accurate data (or) values into inaccurate values is called Quantization. It can be extended to vector data & that procedure is called as vector quantization.
- It maps k dimensional vectors in the vector space R^k into a finite set of vectors Y in the vector space R^k. Vector Y can be given by the equation.

$$Y = \{ y_i : i = 1, 2, \dots n \} \quad \text{—— ①}$$

- Each vector y_i is called a code vector (or) code word & the set of all codewords is called a codebook.
- Associated with each codeword y_i, is a nearest neighbor region called Voronoi region & is defined

$$V_i = \{ x \in R^k : \| x - y_i \| <= \| x - y_j \| \} \text{ for all } j \neq i$$

—— ②

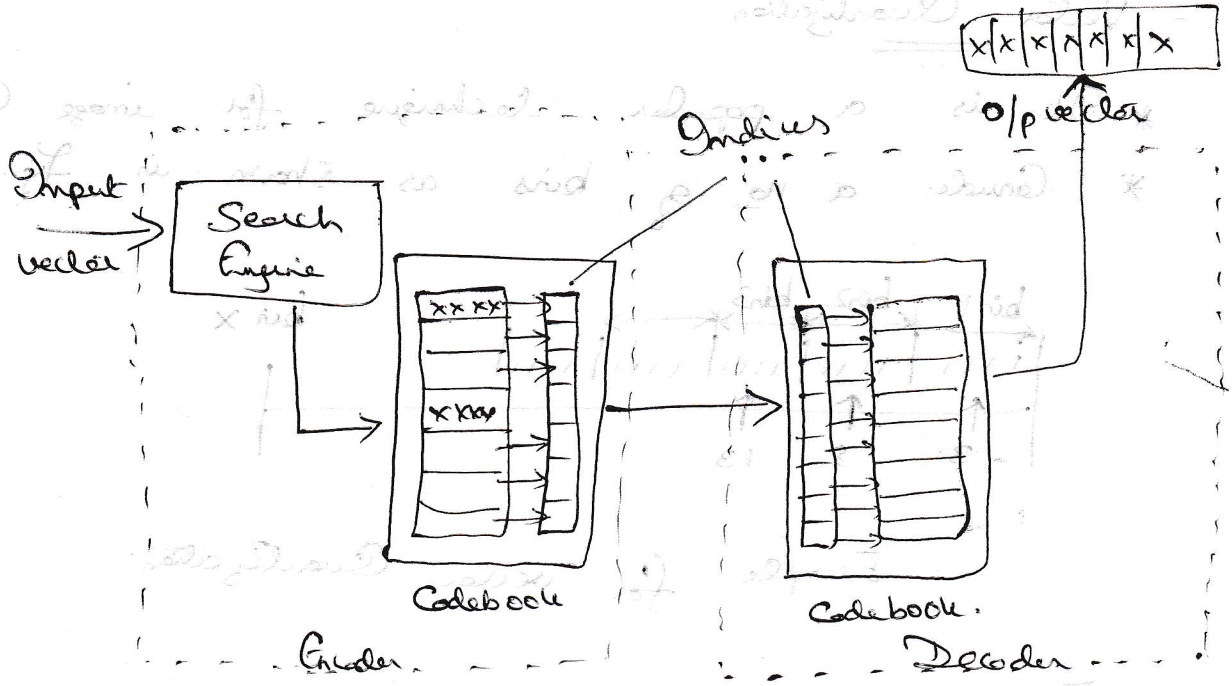


Fig ① : Image Compression technique using vector quantization.

Image Compression Standards.

Binary Image Compression Standards.

- * 1D Compression.
- * 2D Compression.

Most widely $\Rightarrow$ Image Compression stds are CCITT Group 3 & 4 stds for binary image compression

$\Rightarrow$ utilised in FAX.

Group 3 $\Rightarrow$ non adaptive, 1D RLC, $\Rightarrow$ RAC.

Group 4 $\Rightarrow$ Simplified Version of Group 3 Stand
2D Coding is allowed.

$\Rightarrow$ Non adaptive.

Both are used $\Rightarrow$ typed & handwritten text.

$\Rightarrow$ data expansion.

JBIG $\xrightarrow[\text{above problems}]{\text{overcome}}$ [Joint Bilevel Imaging Group].

CCITT & ISO $\Rightarrow$ adopted & proposed several ones $\Rightarrow$ JBIG1 $\Rightarrow$ adaptive

JBIG2 $\Rightarrow$ 2 to 4 > JBIG1.

1D Compression :-

Group 3 Compression $\Rightarrow$ line $\Rightarrow$ Coded as a series
alternating white & black
VLC $\overset{\text{Rep}}{\Rightarrow}$ run lengths of the line.
runs in a left to right scan of the line

* RL $\leq$ 63 ⇒ terminating Code [Modified Huffman Code]

RL > 63 ⇒ Makeup Code. in Conjunction with a terminating code.

* white run length codeword ⇒ 00110101
⇒ white run of length Zero.

* Finally EOL ⇒ end of line Code word.
i.e 000000000001 ⇒ End of a sequence of image by 6 consecutive EOL's

2 D Compression → Group 3 & 4
→ Line by Line ⇒ position of black to white or white to black run transition is coded w.r.t position of a reference element lo
⇒ Coding line
→ Previously coded line is called reference line

* Current reference element & associated changing elements ⇒ 2 tests are performed select one of 3 possible modes ⇒ Pass mode
Vertical mode
horizontal mode

Continuous Tone Still image Compression Standards
⇒ Several Cont tone.
⇒ Lossy transform

Video Compression standards

* 1) Video tele conferencing Stds ⟹ H. 261.
* 2) Multimedia Stds. ⟹ multimedia video Compression Stds ⟹ MPEG 1, MPEG 2 & MPEG 4

MPEG 4

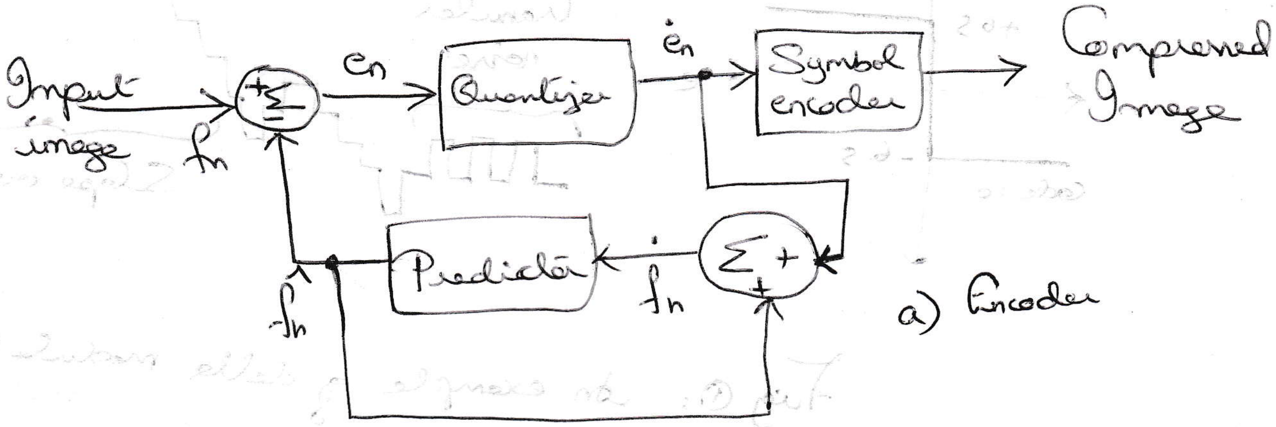
1) Improved Video Compression Efficiency.
2) Content based interactivity.
3) universal access.

Three basic types of encoded o/p frames.

1) I - frame.
2) P - frame.
3) B - frame.

Lossy Compression

Lossy Predictive coding



a) Encoder

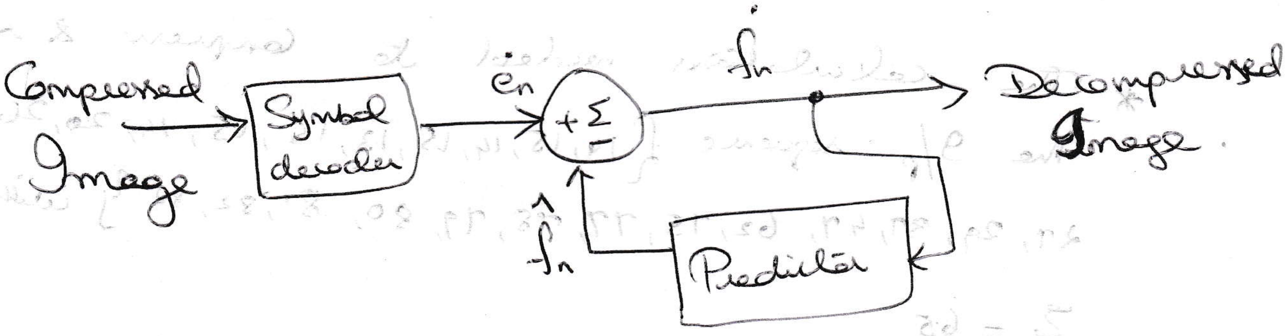


Fig ① : A Lossy Predictive Coding model

b) Decoder

$$\boxed{\dot{f}_n = \dot{e}_n + \hat{f}_n} \quad \text{———} ①.$$

Delta modulation :-

DM is a Simple ⇒ well known form of lossy predictive coding in which predictor & Quantizer

$$\hat{f}_n = \alpha \dot{f}_{n-1}.$$

$$\dot{e}_n = \begin{cases} +\xi & \text{for } e_n > 0. \\ -\xi & \text{otherwise} \end{cases}$$

α is a prediction Co-efficient (normally < 1).

ξ is a +ve constant.

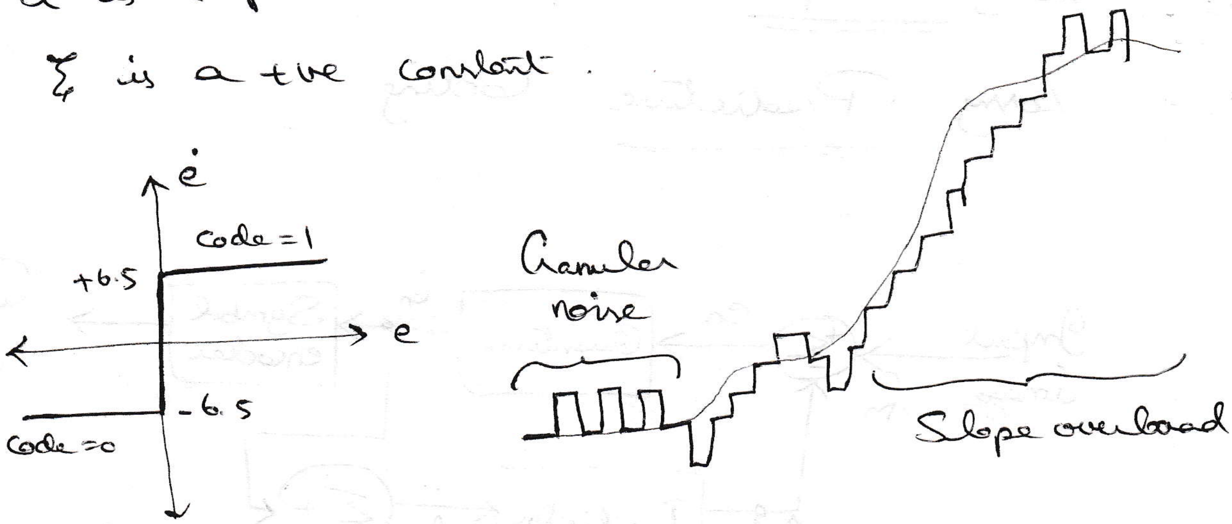


Fig ①: An example of delta modulation.

* The calculations needed to compress & reconstruct the I/p sequence {14, 15, 14, 15, 13, 15, 15, 14, 20, 26, 27, 28, 27, 27, 29, 37, 47, 62, 75, 77, 78, 79, 80, 81, 82, 82} with $\alpha = 1$ & $\xi = 6.5$

* Process begins with error free transfer of first I/p pixel. Initial condition $\dot{f}_0 = f_0 = 14$ established at both encoder & decoder.

* when n=1 $\hat{f}_1 = (1)(14) = 14$, $e_1 = 15 - 14 = 1$, $\dot{e}_1 = +6.5$ (∵ $e_1 > 0$), $\dot{f}_1 = 6.5 + 14 = 20.5$. & The resulting reconstruction error is (15 − 20.5) ⇒ −5.5 gray levels.

rapid changing area

* n = 14 to 19, ξ was too small ⇒ O/p's larger changes
⇒ Slope overload occurs.

* when ξ was too large ⇒ I/p's smallest changes as in relatively smooth region from n=0 to n=7.
⇒ granular noise

Optimal Predictor .

* It is used in most predictive coding applns. minimizes the encoder's mean-square prediction error.

$$E\{e_n^2\} = E\{[f_n - \hat{f}_n]^2\} \quad \text{———} \textcircled{1}$$

subject to the constraint that

$$\dot{f}_n = \dot{e}_n + \hat{f}_n \approx e_n + \hat{f}_n = f_n , \quad \text{———} \textcircled{2}.$$

$$\hat{f}_n = \sum_{i=1}^{m} \alpha_i f_{n-i} \quad \text{———} \textcircled{3}$$

* i.e optimization criterion ⟹ minimise the mean-square prediction error ⟹ Quantization error is assumed to be negligible. $\dot{e}_n \approx e_n$ and the prediction is constrained to a linear combination of m previous pixels.

* These restrictions are not essential, but they simplify the analysis ⟹ ↓ Computational Complexity of the prediction.

* Resulting predictive coding approach is referred to as DPCM [differential pulsecode modulation].

Optimal Quantization :-

Staircase quantization function $t = q(s)$ shown in fig is an odd function of s ⟹ $[q(-s) = -q(s)]$. by $L/2$ Values of s_i & t_i

Values of S_i & t_i ⟹ first quadrant of the graph.

* Break points ⟹ func discontinuities ⟹ Decision & reconstruction levels of the quantizer.

* S is considered to be mapped to t_i if it lies in the half-open interval $(S_i, S_{i+1}]$.

$$\int_{S_{i-1}}^{S_i} (s-t_i)\, p(s)\, ds = 0, \quad i = 1, 2, \dots L/2 \qquad \text{ⓐ}$$

$$S_i = \begin{cases} 0 & i = 0 \\ \dfrac{t_i + t_{i+1}}{2}, & i = 1, 2, \dots, L/2 - 1. \\ \infty & i = L/2 \end{cases} \qquad \text{ⓑ}$$

$$S_{-i} = -S_i \quad \& \quad t_{-i} = -t_i. \qquad \text{ⓒ}$$

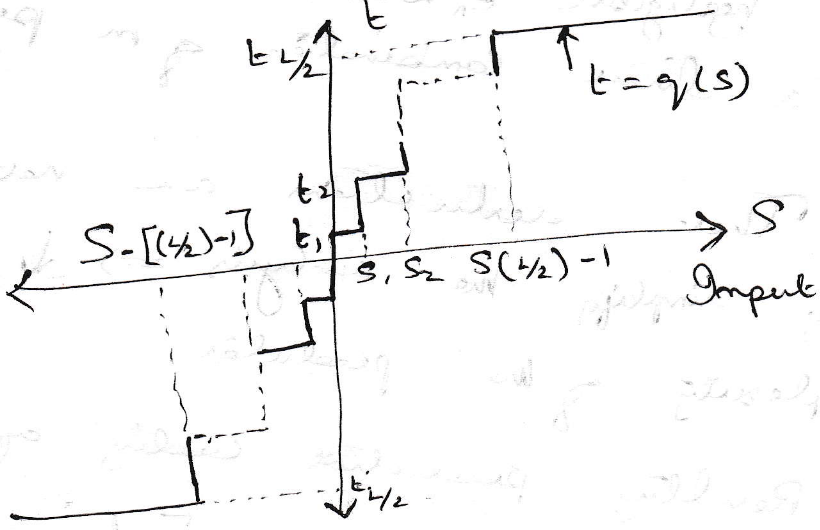


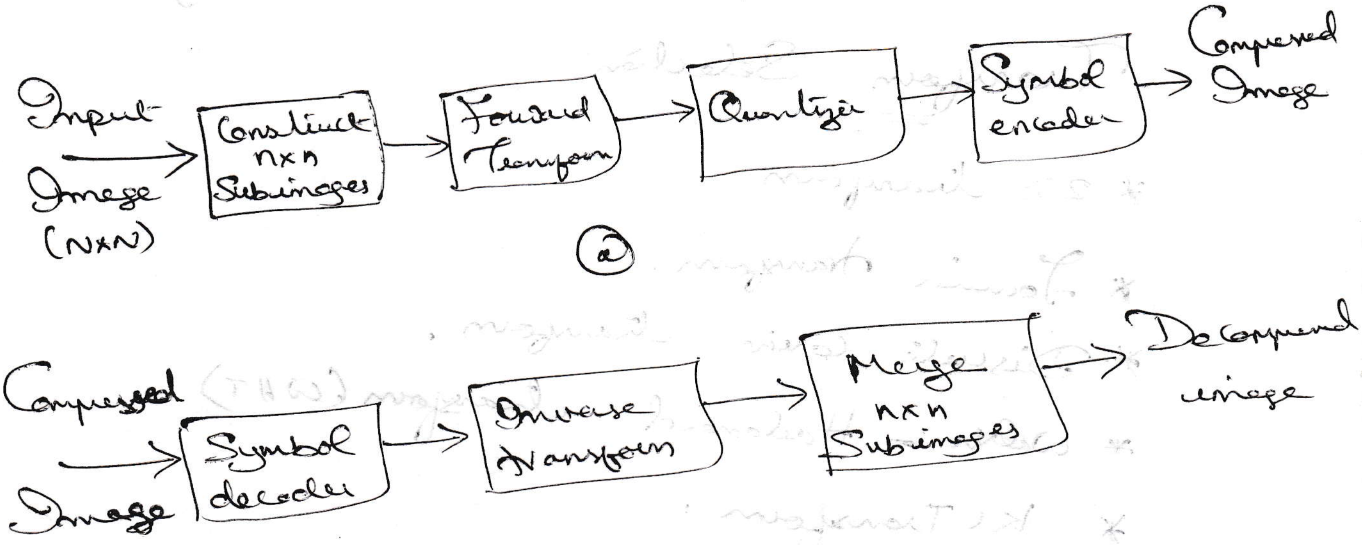
Fig ①: A Typical Quantization function.

* For any L, the S_i & t_i that satisfy eqn ⓐ to ⓒ are optimal in the mean square error sense.

⟹ L-level Lloyd max quantizer.

Transform Coding

* Predictive coding techniques ⇒ Spatial domain methods.
* modifying the transform of the image.
* Transform coding ⇒ A reversible linear transform [Fourier transform]



A transform Coding System

a) Encoder
b) Decoder.

* Goal of transformation ⇒ Decorrelate ~~the~~ pixels of Sub image (or) to pack as much Info as possible into the smaller no of transform Coefficients.

* Quantization ⇒ Selectively eliminates
⇒ more Coarsely Quantizes the Coefficients that carry least Info.
⇒ These Coefficients have the smallest impact on reconstructed Subimage Quality.

- All of the transform encoding steps => Local image content.
  => Adaptive transform coding.

- Fixed for all subimages => Non adaptive transform coding.

Transform Selection

- 2D transform
- Fourier transform.
- Discrete cosine transform.
- Walsh - Hadamard transform (WHT).
- KL Transform.

Subimage Size [allocation] selection

- Significant factor affecting transform coding error & computationally complexity is subimage size.
- Applns => images $\xrightarrow{\text{Subdivided}}$ so that the correlation (redundancy) between adjacent subimages is reduced to some acceptance level, so that n is an integer power of 2 => n is the subimage dimension.
- Level of compression & computational complexity ↑ as subimage size ↑.
- Popular subimage sizes are 8×8 and 16×16.

Bit allocation

* The reconstruction error associated with ⇒ Truncated series expansion of eqn. ⇒ a number & relative importance of transform Co-efficients are discarded, as well as precision that is used to represent the retained Co-efficients.

* Transform coding System ⇒ Retained Co-efficients are selected on the basis of

a) Max Variance → Zonal Coding.

b) Max Mag → Threshold Coding.

Zonal coding ⇒ Information Theory ⇒ uncertainty.

⇒ Replacing Max Variance by 1.

" Min " by 0.

The overall process of Truncated coding, Quantizing & coding the Co-efficients of a transformed Subimage is commonly called bit allocation.

Threshold Coding

* Zonal Coding → Viewing Info as uncertainty.

* Zonal coding → It is Implemented by a single fixed mask of all Subimages.

* Threshold Coding → It is Inherently adaptive i.e adaptive transform coding.

Three ways.

1) A single global threshold → all subimages.
2) Different threshold → Each subimage
3) Threshold → Function of the location of each Co-efficient within the sub image.

* In the first level of Compression ⇒ Varies from image to image
* In Second N largest Coding → Same No of Co-eff discarded for each subimage.
→ Code rate is constant.

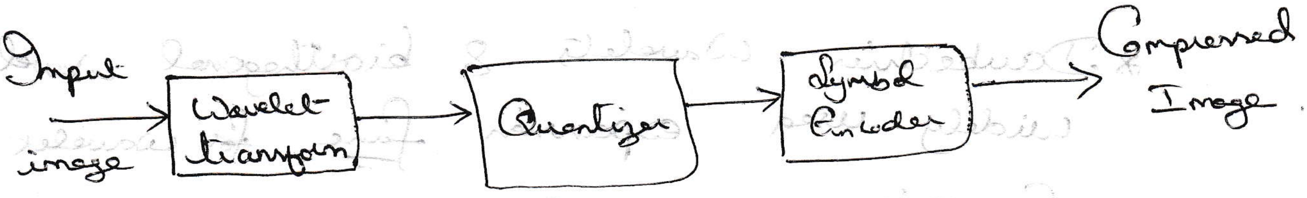
* III^rd technique → Variable Code rate but offers threshold and Quantization.

$$\hat{T}(u,v) = \text{round}\left[\frac{T(u,v)}{Z(u,v)}\right]$$

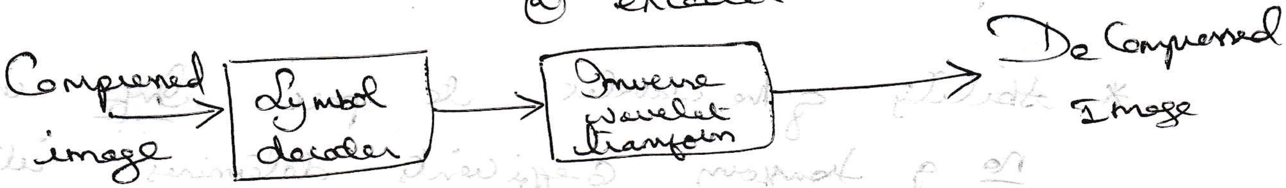
where $\hat{T}(u,v)$ is a thresholded & quantized coff. of $T(u,v)$ & $Z(u,v)$ is an element of transform normalization array.

$$\boxed{kc - \frac{c}{2} \le T(u,v) < kc + \frac{c}{2}}$$

Wavelet Coding



ⓐ encoder



ⓑ decoder

Fig ① wavelet Coding System

wavelet Coding.

* It is based on the idea that the Co-efficients of a transform that decorrelates the pixels of an image can be coded more efficiently than the original pixels themselves.

* Transform's basis functions → Wavelets — Pack most of the important visual Infy into a small no. of Co-efficients, the remaining Co-efficients can be quantized Coarsely (or) truncated to Zero with image distortion.

* Diff between Wavelet & transform

* It is Computationally efficient & inherently local. [basis functions are limited in duration], Subdivision of the original image is unnecessary.

* Removal Subdivision → Eliminates the blocking artifact that characterizes DCT based app at high Compression ratios.

Wavelet selection

* Daubechies Wavelets & biorthogonal wavelet → widely used expansion func for wavelet based Compression.

* Ability of the wavelet to pack Inf into a small No of transform co-efficients determines its Compression & reconstruction performance.

Decomposition level Selection

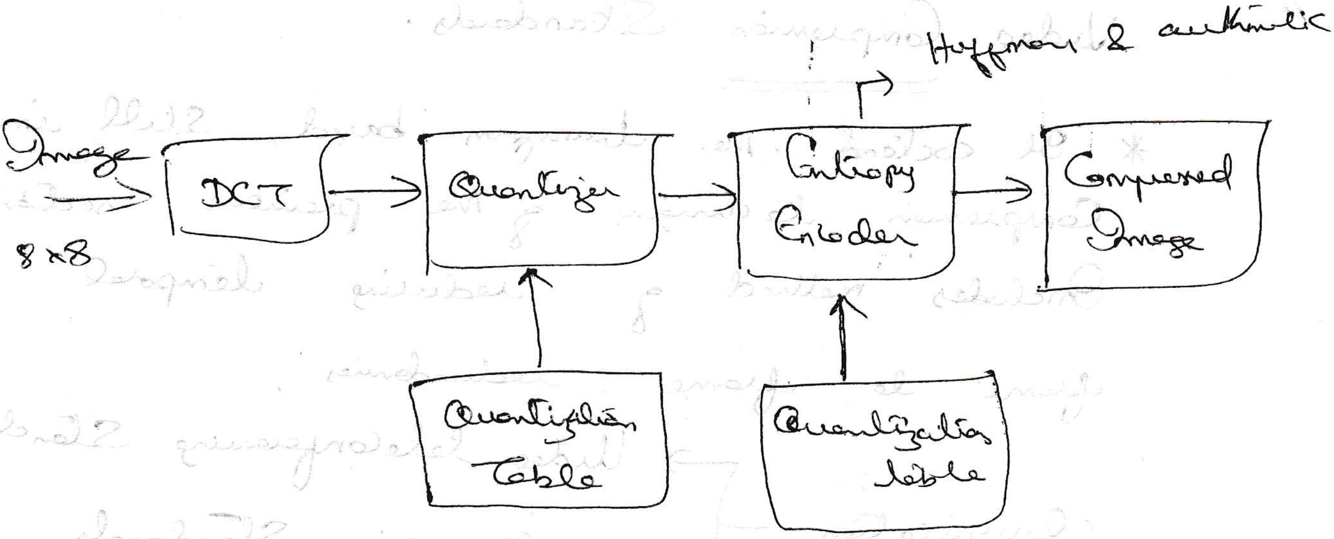
* No. of transform decomposition levels.
* P-Scale wavelet transform Involves P filter bank iterations, No. of operations in the computation of the forward and inverse transforms ↑ with No. of decomposition levels.

Quantizer design.

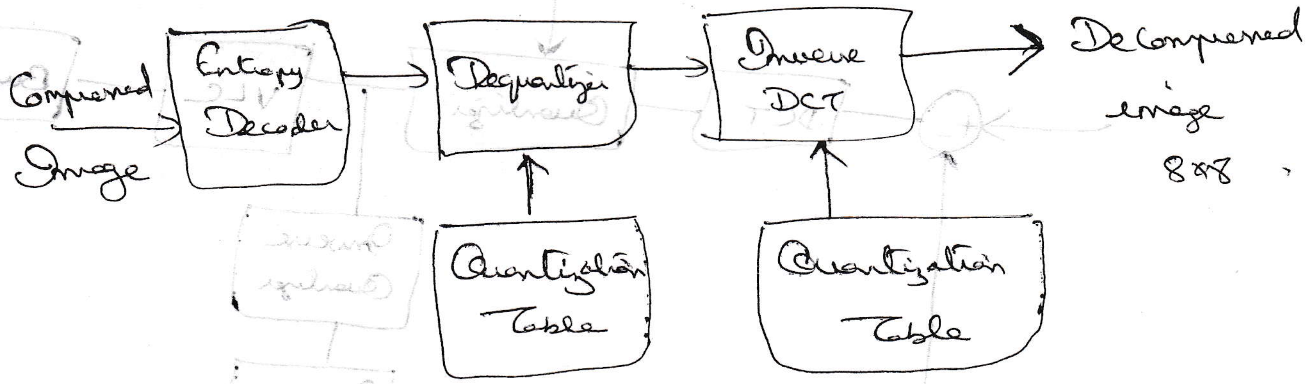
* Largest factor affecting wavelet Coding Compression & reconstruction error is coefficient quantization.

* Quantizers are uniform → 1) Introducing an enlarged quantization Interval around Zero called a dead Zone (or) 2) adapting the size of the quantization interval from Scale to Scale.

* Selected Quantization levels must be trans to decoder with encoded image bit stream.



JPEG Encoder



JPEG Decoder

* DC Coefficients & AC Coefficients

JPEG

3 different Coding Systems

i) Lossy baseline Coding System → Based on DCT & adequate for most compression applns.

ii) Extended Coding System → greater compression higher precision (or) progressive recons applns.

iii) Lossless independent coding system → Reversible compression.

Video Compression Standards.

* It extends the transform based, still image Compression techniques of the previous section => Includes method of reducing temporal (or) frame to frame redundancies.

Classification → Video teleconferencing Standards.
→ Multimedia Standards.

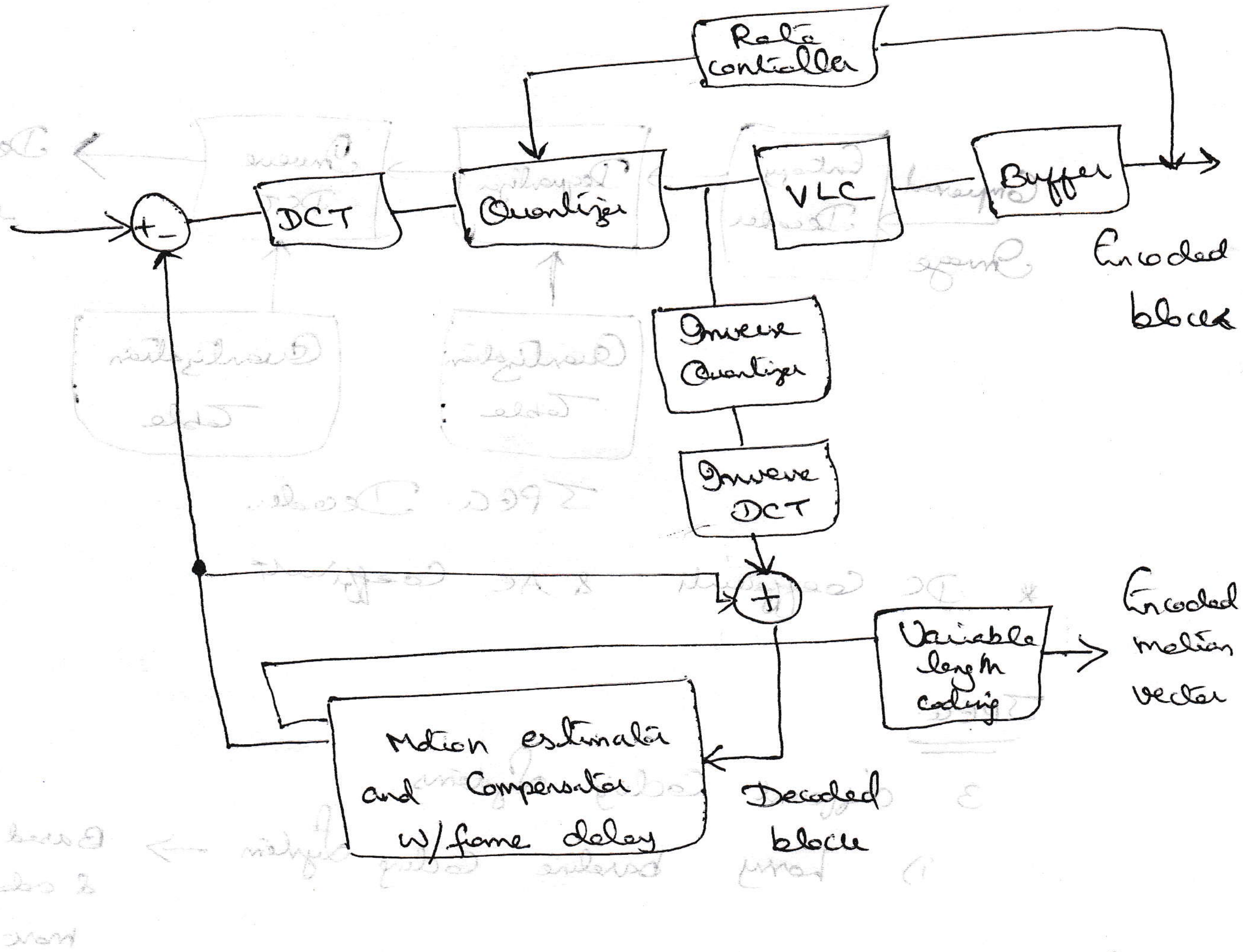


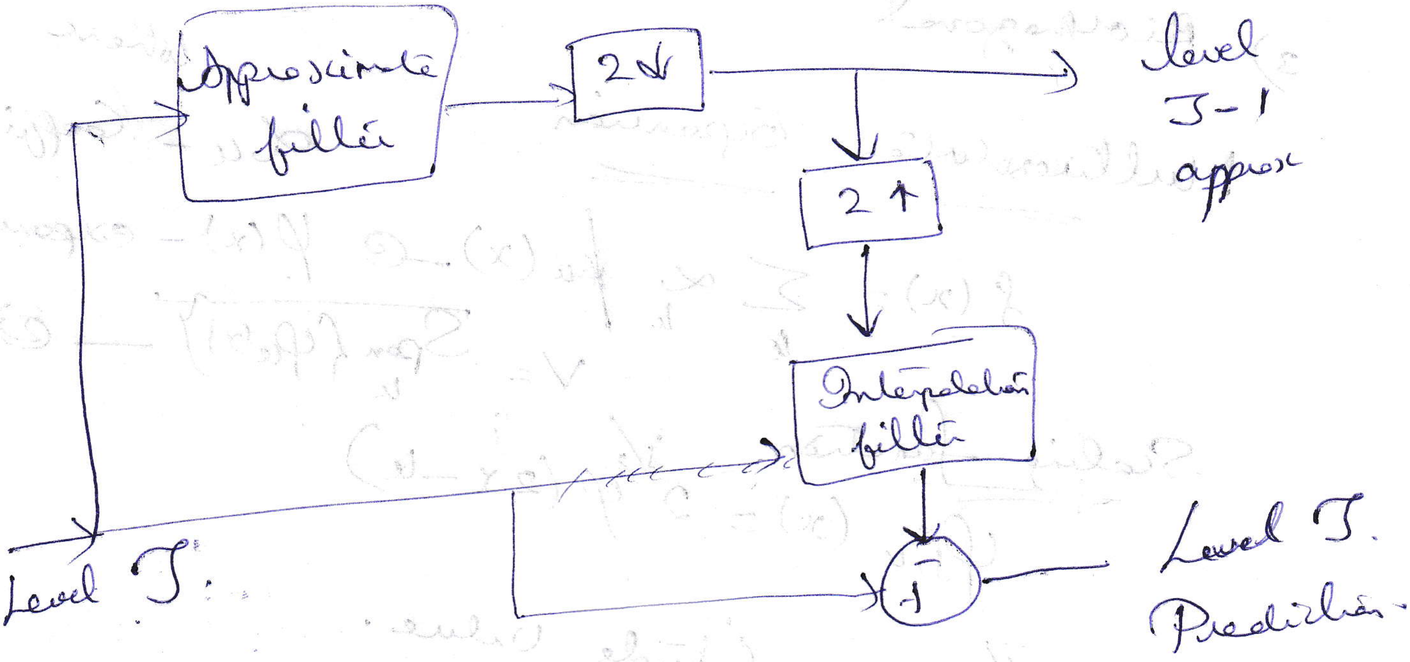
Fig ①: Basic DPCM/DCT Encoder for motion Compensated Video Compression.

Basic types of encoded o/p frames

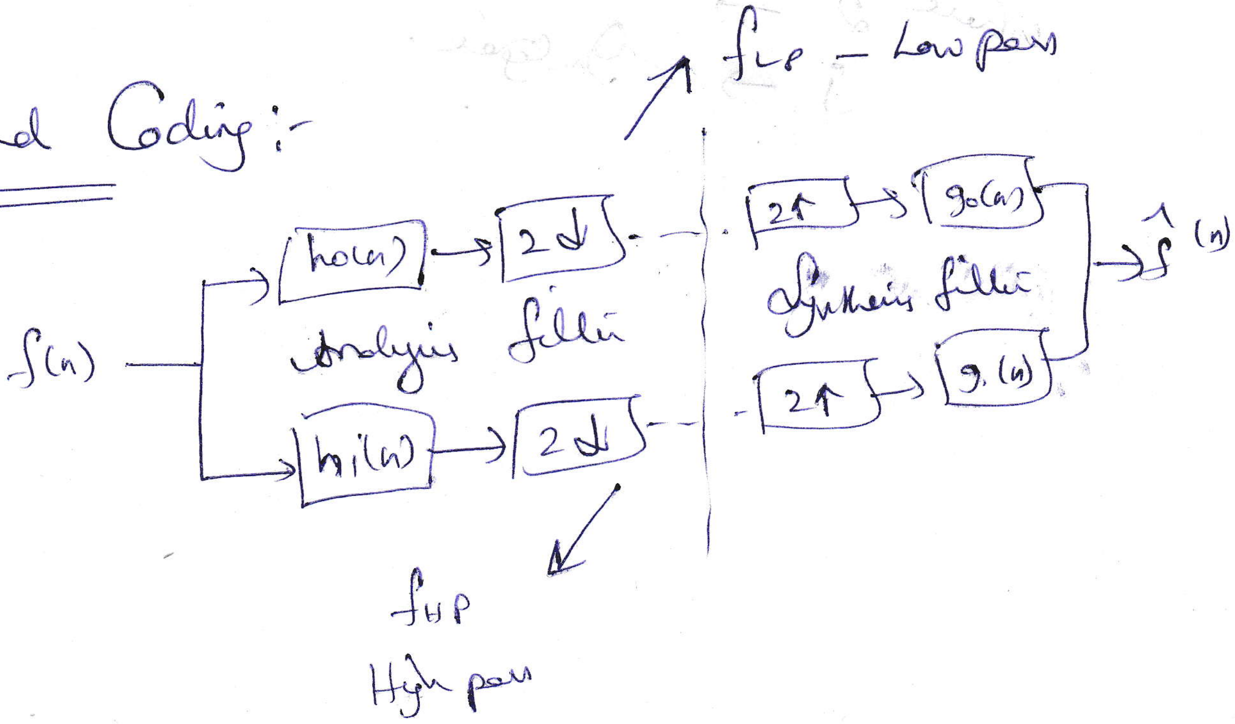
i) Intra frame (or) independent frame (I-frame)
ii) Predictive frame (P-frame)
iii) Bi directional frame (B-frame).

Wavelets

- → Image Pyramids
- → upsampling ⟹ $f_{2\uparrow}(n) = f(n/2)$
- → Downsampling ⟹ $f_{2\downarrow}(n) = f(2n)$.



Subband Coding:-



///ly For L&H freq Component

Conditions

1) orthogonal
2) orthonormal
3) Biorthogonal

Multiresolution Expansion

$$f(x) = \sum_k \alpha_k \varphi_k(x) \quad — ①$$

$$V = \overline{\text{Span}_k \{\varphi_k(x)\}} \quad — ②$$

where

α_k - Coefficient

$\varphi(x)$ - expansion

Scaling function

$$\varphi_{j,k}(x) = 2^{j/2} \varphi(2^j x - k)$$

where $2^{j/2} \rightarrow$ amplitude value.

$j \rightarrow$ Integer.