**II MSC-CS**

**DIGITAL IMAGE PROCESSING**

**Unit - IV**

 Image Restoration .Image observation Models, Source of degradation, inverse and wiener filtering, geometric mean filtering, non linear filter, smoothing splines & Interpolation constrain least square restoration

**Unit-V**

Image data compression & Image reconstruction from projection compression Image data rates. Pixel coding, predictive technique transform coding & vector DBCM, block truncation coding wavelet transform coding of images color image coding.

 Random Transform back projection operator, Inverse Random Transform back projections operator, Inverse Random Transform, back projection Algorithm of an been and Algebraic restoration technique.

BOOK FOR STUDY:

1. Anil K. Jain,” fundamentals of digital image processing”, PHL,1993.

2.Sid Ahmed M.A ’Image processing”, McGraw hill Inc, 1995.

3. Gonzaloz Rand win Z P “digital image Processing”, Addition usely 2nd Ed 1987.

**UNIT – IV**

**2MARK**

**1. Define Image Restoration:**

Image restoration refers to removal or minimization of known degradation is in image. Image restoration is concerned with filtering the observed image to minimize the effect of degradation. The effectiveness of image restoration filter depends on the accuracy of the knowledge of the degradation process as well as on the filter design criteria.

**2. Define MSE**

MSE—> Mean Square Error.

It find out the different square between original to processed or capture image.

**Define smoothing splines**

Smoothing splines are curves used to estimate noisy observed function are useful for making image as more visible magnification and noise smoothing.

**5MARK**

**1. Explain Image Observation Model**

A typical imaging system consists of an image formation system.

A detector and a Recorder for example an detector optical system such as the television camera contain an optical system.

That shows as an image on photo electric devices. Which is scanned↓ for transmission and Recording of the Image?

Image Restoration

Linear Filtering

Other Methods

Restoration Model

1.Image Observation Model 1.Inverse/ pseudo inverse filter 1.Maximum entropy Restoration

2. Image formation Model 2. Wiener filter 2. Poison Methods

3. Noise Models 3. FIR Filter 3.Coordinate Transformations

4.Sambled observation Model 4. Generalized wiener filters 4. Geometric correction

 5. Spline Interrogational Smoothing 5.Blind Devolution

 6. Least Squares and SVO Methods 6.Extrapolation 7.Semi cursive filter

[Similarly an ordinary camera uses a lenses to form an image that is detected an recorded on a photo sensitive film.

The general model for such system can be expressed as

v(x,y) = g[u(x,y)]

v(x,y) observed image

g(x,y) detector

u(x,y) original Image

u(x,y) v(x,y)

g(x,y)

 Image observation Model

u(x,y) original image

g(x,y) detected image

v(x,y) observed image

The image formation process can off an be model by the linear system

u(x,y) v(x,y)

g(.)

g(.) Linear system

u(x,y) original image

v(x,y) observed image

Image Formation Model:

1. Photometric image formation
2. Digital image formation
3. photometric image formation, A simplified model of photometric image formation.



Light is emitted by one or more light source and is then reflected from an object surface. A portion of this light is directed to words to the camera. The directed light is detector & recorded or stored using specific recorder ignores multiple reflections.

**Noise Model:** the general noise model can be expressed as,n(x,y)=u(x,y).n1(x,y)

n1(x,y)🡪specified type of noise.

n(x,y)🡪noise model

**Detector and recorder model**: the response of the detector and recorder is generally non linear. The result of the detector and recorder can written as

β = α w

Where, α β = detector, β = Recorder

w=input image

**2. Explain Geometric Mean filter:**

In the geometric mean method the color value of each pixel is replaced with geometric mean of color values of the pixel in the surrounding region.

A Larger religion fields a stronger filter effect with the blurring. The geometric mean is defined as

$$G=\sqrt{a1},a2……an$$

Here, G-Geometric mean value

A1,a2,….an – set of n values of image.

 The geometric mean is a type of mean value or average which indicate of typical value of a set of Numbers by using the product of the values.

The geometric mean is defined as the nth root of the product of N numbers. That is for a set of numbers xi N

 1

The geometric mean for the above set of number is defined as

For example 2 and 8 is defined as

G= $\sqrt{2.8} = \sqrt{16} =4$

G=4

G= $\sqrt{5.2.3.4.6} = \sqrt{720} = 12 \sqrt{5}$

**Advantages:**

The geometric mean filter is better at removing Gaussian type of noise.

Geometric mean filter preserving edge features then the arithmetic mean filter.

**3. Explain Smoothing splines and interpolation**

Smoothing spline is a method of smoothing (filtering a smooth curve to a set of Noisy observation) using a spline function.

Definition:

Let (xi,yi)

Xi= set of observation. Xi=x1,x2,…..xn

modulated by the relation yi= µ (xi)

Smoothing splines are curves used to estimate noisy observed function are useful for making image as more visible magnification and noise smoothing.

Typically, pixels in each horizontal scan line are first fit by smoothing spline and then finally it achieve a desired magnification in the horizontal direction.

The same procedure is then replaced along a vertical direction. Thus the image is smooth and interpolated by a separate function.

Let xi 0 ≤ I ≤ N be a given set of a function f(x), the set of observation is defined as

yi=f(xi) + n(xi).g(xi)

here, f(x) – set of observation

 n(xi) – Noisy function

 g(xi) – Spline function

 y(xi) – Smoothing observed area ]3

**4. Explain least square filter:**

Least square filter are a class of the adaptive filter used to produce least mean square of the error signal.

Adaptive filter:

An adaptive filter is a system with a linear filter that has a transferred function controlled by variable parameter and means to adjust that parameter according to an optimization algorithm.

It is a stochastic gradient descent method in the filter is only adapter based on the error at current time.

The idea behinds least mean square filter is to approach the minimum filter weight by updating a filter weight to the optimum filter weight.

The algorithm start by small weight (zero assuming 0 ) and each stop finding the grading of the mean square error, the weight are updated.

 X(n)

E(n)

H(n)

 Y(n)

 Y(n)=e(n) € x(n).h(n)

The least mean square approach toward to find optimal weight by ascending/ descending down the mean square error.

**10MARK**

**1. Explain Inverse and wiener filtering**:-

**Inverse**: Inverse filtering is the process of recovering the input of the system from its output for example is the absence of noise the inverse filter would be a system that recovers u(m,n) from the observation v(m,n).

This means h’(m,n;k,l) = h (m,n;k,l)

 Input image observed image

Inverse filter are useful for pre correcting an input signal in anticipation of the degradation caucused by the system.

It corrects the non linearity of a display.

u(m,n) u1(m,n)

H1(m,n;k,l)

G1(.)

G(.)

M,n ; k,l

g(.)-function for linear u1(m,n)-recover image

w(m,n) -noise free image v(m,n)-observed image

u(m,n)-original image (k,l)-average filtering weight

**Wiener Filtering:**

The main limitation of inverse filtering is that’s the inverse filter very sensitive to noise. Wiener filtering is a method of restoring image in the presence of blur as well as noise.

The Weiner filter is a filter is used to produce an estimate of a desire are target process of on observe noisy process. The Wiener filter minimize the means square error between the estimated process and the desire process.

Let, (m,n) and v(m,n) o mean random sequences. It is desire to obtain an estimate u(m,n) of u(m,n) from v(m,n).

e(m,n) = (u(m,n) – u1(m,n))2

The mean square error e(m,n) is minimized for every (m,n), that is u(m,n) = (E(m,n;k,l)) Therefore one general best linear estimate of the form

U(m,n)=$∑$∑ e(m,n;k,l)

The wiener filter is used to achieve Zero mean sequence.

U1(m,n)=u(m,n)\*n(m,n)

U(m,n)=u1(m,n)\*(k,l)

**Pseudo inverse filter:**

In protective the inverse filter of the smoothing function H(u,v) will contain zero values so the inverse filter will be undefined at those frequencies.

The pseudo inverse filter avoid these zero values by ignoring bad frequencies.

The pseudo inverse filter can be expressed as

p(u,v) = if H(u,v) =0 ignored

 H(u,v) otherwise

Here, p(u,v) – pseudo inverse filter

 H(u,v) – Smoothing function

The pseudo inverse filter convert the image into unsigned byte data types. So it do not causes any problem with our virtual perception of the image.

It plays an important role in image restoration.

**2. Explain Non Linear Filters**

Digital implementation of Non-linear filter is Quite easy. A simple Non-linear filter called the root filter. Depending upon the value of the filter. It could be differentiae as high pass, low pass and band pass filter.

In signal are image processing a non-linear filter is a filter whose output is not a linear function that is if the filter output signal R and S for the input signal; of r and s. The linear sequences of input (r and s) are respected by applying the Non-linear filter.

Both continuous domain and discrete domain filter maybe non-linear.

 The Non-linear filter is applicable in both continuous domain and discrete domain the non-linear filters are considerably harder to use and design the linear filter. Because the most powerful mathematical tools of signal analysis used on them.

**Noise Removal in Non-linear filter:**

When the desire signal S gets added with unwanted signal N that has connection with S using the non-linear filter the N can be removed in the following manner.

u(m,n) = S(m,n) x N(m,n)

The Fourier transform for corrupted signal is F (w1,w2).

F(N1,w1,w2) – Fourier transform with Noise.

F=∑∑[n/∞(w1,w2)]

Here, W1,W2 – frequency values

α- filtered weight

N- Noise

Depending upon the value of α it could be α – low pass, high pass or a band pass filter.

 N=1

The α is reduced to N.

The noise free image of the signal F(w1,w2) can be expressed as

**Benefits or Advantages of Non-linear**

Some sort of non-linear filter will be needed for maximum signal recovery. The non-linear filter is used to reduce multiplicative Noise.

Non linear filter are preserve overall information content.

The Non linear filter is to preserve sharpness.

Non linear filter give more efficient result]

**UNIT – V**

**1. Define Image Compression:**

Image data compression is concerned with minimizing the number of bits required to represent an image. Perhaps the simplest most useful form of data compression is the sampling of band limited images, where an infinite no. of pixel per unit area is reduced to one simple with any loss of information.

**2. Write any two applications of image compression**

Image storage is required for educational business document, Medical Image computer to monographic – (T Scanner) MRI – Magnetic Resonance Imaging) and digital radiology, motion picture, weather maps.

**3. List out the image compression techniques**

 Image Data Compression Techniques

Transform Coding

Pixel Coding

Other Methods

Predictive Coding

1. PCM/Quantization 1. Delta Modulation 1. Zonal Coding 1. Hybrid Coding
2. Run- length coding 2. Line by line DPCM 2.Threshold coding 2.Two- tone/ graphic coding
3. Bit – plane coding 3. 2D DBCM 3. Multi Dimensional Technique 3. Color Image coding

 4.Interframe techniques 4. Adaptive 4. Vector Quantization

 5. Adaptive 5. Miscellaneous

.

**4. Define Predictive coding**

 This method used to exploited redundancy in the data. for an example : An image of constant gray level is fully predictable once that gray level of the 1st pixel is known. On the other hand a weight noise random field is totally unpredictable an every pixel has to be stored to reproduce the image.

**5. Define Transform coding**

 In this method, compression achieved by transforming the given image in to another array. Such that a large amount of transformation is packed in to a small no. of samples.

 Other image data compression algorithm exists that are generalization or combination of there method.

**6. Define Image data rate**

 Typical television images have special resolution of approximately 512 x 512 pixels (per frame ). At 8 bit per pixel per color channel and 30 frame per second, this translate a Rte of nearly 180x106 bits. Depending on the application, digital image raw data rate can vary from 105 bit/frame to 108 bit/frame or higher. Large channel capacity and memory requirement for digital image transmission & storage makes it desirable to consider data compression technique.

**5 MARK**

**1. Explain DPCM:**

 The coding process continuous recursively in this manner. This method is called DPCM. (Differential pulse code modulation) or differential PCM.

Communication Channel

Quantized

Predictor

Predictor

The above figure consist codes and decoder. The coder has to calculate predicted sequence with error. The decoder has to calculate the reproduced sequences.

**Feedback versus feed forward prediction**:

An important aspect of DPCM is in which says the predication is based on the output. The quantized samples rather than the inputs –the un quantized samples.

 This result in the predictor being in the feedback loop around the quantized, so that the quantized error at the given step is feedback to the quantized input at the next step.

If the prediction rule is based on the passed input, the signal reconstruction error would depend on the past and present quantization error inb the feed forward prediction-error sequence.

Generally the mean square error value of this reconstruction error will be greater than that in DPCM.

**2. ExplainVector DPCM:**

**Vector data model:** Vector models are used for storing data that has decorated boundaries. Raster data model representation of the surface divided into regular grids of cells.

Raster models are useful for storing the pixel data.

|  |  |
| --- | --- |
| Raster scan | Vector scan |
| 1.It can draw areas filled with colors | It can only draw lines |
| 2.Scanning is done one line at a time form top to bottom and left to right | Scanning is done between the end point |
| 3.Even for a complex image a raster can display does not flicker | For a complex image a vector scan display may flicker. |
| 4.Raster scan is converted to pixel | Vector scan is not converted to pixel  |
|  |  |

 **VECTOR DPCM**: If the images is vector scan, then it is possible to generalized the DPCM technique by considering vector recursive predictor.

 Hybrid coding is the method of implementing n\*1 vector DPCM coder. Typically the images unitarily transformed in one of its pixel in that direction.



Each transform co-efficient is then sequentially coded in the other direction by one dimensional DPCM. This technique provide robust performance of transform coding hybrid coding defined as,

Let un (n=0,1,2….) n\*1 column of an image ,which are transformed as vn= ¥ u(n)

The dpcm equation can be written as

 e(n)= v(n) –v$\^$(n)

 u(n)=e(n)+va(n)

The receiver simply reconstruct the transformed vector according to perform the inverse transformation(y, ¥).

**3. Explain Block truncation coding** or block transform coding:

In this section we consider a compression technique that device an image in to small non over lapping blocks of equal size for example (8\*8). And process as the blocks independently using the 2d transform. In block transform coding a linear transform (such as a furrier transform) is used to map each blo0ck or sub image in to a set of transform co-efficiency, which are then quantized and coded.



The above figure shows a typical block transform coding system. the decodes implements the inverse sequence of steps of the encoder, which perform four relatively straight forward operations. Sub image d composition, transformation.

**Quantization and coding:**

 An m x n input image is sub divided in to n x n sub images, which are then transform to generate MN/N2  sub image transform arrays, each of size n x n.

The goal of the transformation is to pack as much information as possible into the smallest number of transform co-efficient.

 The quantization then selectively eliminate the repeated co-efficient .these co-efficient has the smallest impact on reconstruct the sub image quality.

The encoding process terminates by coding the quantized co-efficient.

**Transform selection:**

 Block transforms coding system based on a verity of discrete 20 transform. The choice of a particular transform in a given application depends on the amount of reconstruction error.

 Consider a sub image f(x,y) of size n x n whose forward discrete transform T(u.v) can be expressed in terms of the general relation

T (u,v)=∑n-1 ∑n-1  g(x,y)0r (x,y,u,v)

g(x,y)=similarly can be uptained using the generalized inverse discrete transform.

g(x,y)= $\sum\_{u=0}^{n-1}\sum\_{v=0}^{n-1}T\left(u,r\right)S (u,v,x,y)$

In this equation r(x,y,u,v) and s(x,y,u,v) are called forward and inverse transformation.

**4. Explain Wavelet transforms coding:**

In mathematics wavelet series is the representation of real and complex numbers. In two dimensional, a scaling function is Ø(x,y) .

The wavelet transform for this two dimensional scaling vector requires the following 3 vectors.

 ¥ -wavelet

 ¥H (x,y) –wavelet transform vector for horizontal values

 ¥V (x,y) – wavelet transformation vector for vertical values

 ¥D (x,y) –wavelet transformation vector for dimensional values

The wavelet transformation expression can be defined as

¥H (x,y) => ¥(x) Øy.

¥V (x,y) => Øx ¥ (y)

¥D (x,y) => ¥ (x) ¥ (y)

Wavelet coding is based on the idea that the co-efficient of the transform that decor relate the pixels of an image can be coded more efficiently then the original pixels them solves.

In the case of wavelet pack most of the important visual information in to a small number of co-efficient with zero mean.

The computer transform convert a large portion of the original image to horizontal, vertical and diagonal decomposition co-efficient with zero mean.

(In other transformation) Many of the computed co-efficiency carry little visual information, they can be quantized and coded redundancy.

(Inverter inverse of encode);

Decoding is accomplished by inverting the encoding operation.

 A wavelet coding system



The principal difference between the wavelet based system and other transformation coding system is to omit the sub image process of the transform coder.

**Advantages:**

1. Wavelet transform provide computational efficiency.

2. Sub division of the original image is un necessary.

3. The construction of the image is provided with zero mean.

The ability of the wavelet to pack information into a small no. of transform co-efficient determines. Its compressions and reconstruction performance.

**10 MARK**

**1. Explain Transform coding:**

 Transform coding, also called block quantization, is an alternative to predictive coding. a block of data is unitarily transform so that the large fraction of its total energy is packed in relatively few transform co-efficient, which are quantized independently.

 The optimum transform coder is defined as the one that minimize mean square error of the reproduced data for a given no. of total bits.

One-dimensional transform coding:

 Suppose an N\*1 random vector u is linearly transform by an N\*N matrix. A. it produce as a vector v and its component x (k) are mutually uncorrelated



After quantizing each component v(k) independently, the output vector v’ is linearly transform by a matrix B to yield a vector u’.the optimal coder is need to reduce mean square error value.

(Distortion) error

D=$\frac{1}{N}$ E$\left[\sum\_{n=1}^{N}(u\left(n\right)-u^{1}\left(n\right))^{2}\right]$

The optional transformed coder has minimum D value.

**Transformational coding of images:**

 to make transform coding practical, a given imager is divided into small rectangular blocks, an each is transform coded independently for an N\*M image divided into NM/PQ. Each of size P\*Q the main storage requirement for implement the transform or reduced by a factor NM/PQ.

For example 512\*512 image a divided into 16\*16 blocks. these factors are 1024 respective

Two dimensional transform coding algorithm consist the following step:

1**. Divided the given image**: => Divide the image into small rectangular block o size p\*q so therefore

ui=> value of block

 i=>0 to i-1

2. **Transform a block:** => calculate the transform co-efficient.for example estimated co-efficient =vi(k,l)

**3. Code the out put:** => using the coder code the output into code words and transmit or stored.

**4. Reproduce the co-efficient** :=> using the decoder the co-efficient are reproduced

**2. Explain Pixel coding**

 In this technique each pixel is processed independently, ignoring the inter pixel dependencies.

* + PCM(Pulse Code Modulation)
	+ Entropy coding
	+ Run length coding
	+ Bit plane coding

**PCM: (pulse code modulation)**

 In PCM the incoming video signal is sampled. Quant sized and coded by a shoo table code word (below bleeding it to a digital. Modulator for transmission.

 The quantities output is generally coded by a fixed length binary code word having 8 bits.

 Commonly 8 bits are sufficient for monochrome brought cast; where as medical images are color video signals may require 10 to 12 bits per pixel.

**Entropy coding:-**

 Entropy coding is a listless data compression scheme. One of the main types of entropy coding creates and assigns a unique free code to each unique symbol. That occur in the input.

 There entropy encode are then compress data by replacing each fixed length input symbol with the corresponding variable.

The length of the each code word is approximately propos anal to the negative logarithm of the probability.

 The most common symbol use the snottiest code:

 The optimal code length of the symbol is log P.

b is the input symbol

P is the proportional value

 If the quantized pixels are not uniformly distributed, then there entropy will be less than B in entropy coding the goal is the encode a block of pixels values.

**Run length encoding:**

 Consider a binary source where output is coded as the no of zeros between two successive once. That is the length of the runs of zeros is coded. This is call run length coding (RLC).

Run length encoding:-

 It is every simple form of data compression in which run of data (that is, sequence in which the same data value occur in many consecutive data elements).are stored as a single data value and count, rather than as a original run.

 That is most useful on data that contains many such runs.

 Consider a screen containing plain black text on a field white background.

 Their will be many long runs of white fixed in that black space and many short runs of black pixels.

 ex: x x x x x x x x x x x

 =10x.

 A hypothetical scan line with B representing black pixels and W representing white. With the run length encoding data compression algorithm applied to the below scan line it can be render as follows :

 5w1b5w3b7w2b2w

**=> Application;**

 Run length en coding performs lassoes data compression and is well shouted to bit map images such as icons. it is not work well at all on continuous tone images. Such as photograph.

 R/E is used in fax machine combined with other technique.

 It is relatively efficient because most faxed document or generally white space, with occasional interruption or block.

**=>Bit plane encoding;**

 A bit plane of a digital discrete signal (such as image or sound) is a set of bits corresponding to a given bit position in each of the binary number representing the signal.

 For example 16 bit data representation there are 16 bit planes. The first bit planes contain the most significant bit .the 16th bit or the nth bit plane contains the least significant bit.

a 256 gray level image can be considered as a set of 8(1(bit)) planes, each of which can be run length encoded.

 eg: 1 1 1 1 1 1 1 1

 27 26 25 24 23 22 21 20

p (x,y)=f(x-1,y)

 p (x,y)=[f(x-1,y)+ (x,y-1)]

We then calculate the prediction error e (x,y) = F(x, y) - p (x,y)

 (error value) (original value) (prediction value)

This prediction error will be less correlated to an input images.

 Consider a sampled sequence u(m), which has been coded up to m(sequence)=n-1 (no. of values) and let u(n-1),u(n-2)………. be the values of the reproduced sequence.