B.Tech

(SEM..VII) ODD SEMESETER THEORY EXAMINATION, 2010-11

DIGITAL IMAGE PROCESSING

Time: 3 Hours *Total Marks:* **100**

Note: *Attempt any five questions. All questions carry equal marks. Assume missing data suitably, if any.*

1. Attempt any four parts of the following: **(5×4=20)**

Q.1. (a) Draw the block diagram of digital image processing.

Ans. An image may be defined as two dimensional function, $f(x, y)$ where x, y are spatial coordinates and amplitude of f at any pair of coordinates (x, y) is called intensity or gray level of image at that point. When all amplitude values are finite and discrete its called digital image. The digital image processing means processing digital images of means of a computer.

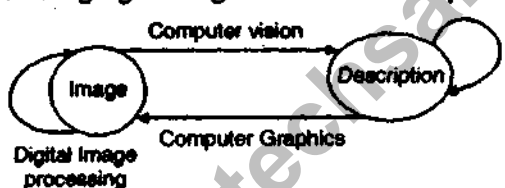

Fig. 1.

Q.1. (b) Can two monochromatic sources with different wavelengths can be perceived to have same colour ? Explain.

Ans. Take a glass plate and illuminate it from the bottom with constant illumination I.

Now, observer is asked to look at it and intensity is increased from $I \rightarrow I + \Delta I$.

Let ΔI_c be intensity increase where user note the difference.

Then Weber Ratio = $\frac{\Delta I_C}{I}$

Now, if we have 2 separate sources but they fall within range of weber ratio, then although being different they are perceived to be coming from same source.

Q.1. (c) Discuss the features of optimum mean square quantizer.

Ans.

(*i*) The quantizer output is unbiased estimate of input i.e., $E[\hat{f}] = E[f]$

$\Rightarrow$ SNR for uniform quantizer increases by 6 db/bits

(*ii*) The quantizer error is orthogonal to quantizer inputs i.e., $E[(f - \hat{f})\,\hat{f}] = 0 \Rightarrow$ quantization noise is uncorelated with quantized output.

(*iii*) The variance of quantizer output is reduced by factor $[1 - f(B)]$ where $f(B)$ denotes mean square distortion of B-bit quantizer.

i.e., $\sigma_{\hat{f}}^2 = (1 - f(B))\,\sigma_f^2$

(*iv*) It's sufficient to design mean square quantizer for zero mean and unity variance distributions.

Q.1. (d) Compare CCD and CMOS image sensors.

Ans. CCD Vs CMOS: A CCD is an analog device. Wen light strikes the chip its held as a small electrical charge in each photo sensor. Charges are converted to voltage one pixel at a time.

A CMOS chip is a type of active pixel sensor made using CMOS semiconductor process. Extra circuiting is needed next to each photo sensor to convert light energy to voltage.

CCD's are more susceptible to verticals mere from bright light.

CMOS can be implemented using fewer components use less power and provide fast radiant. CMOS are less expensive than CCD.

Q.1. (e) Distinguish between sampling and quantization.

Ans. A digital image has 2 major parts:

(*i*) Coordinate values of pixels.

(*ii*) Gray value of each pixel.

Digitizing the coordinate values is called *sampling*. Digitizing the amplitude values is called *quantization*.

Example

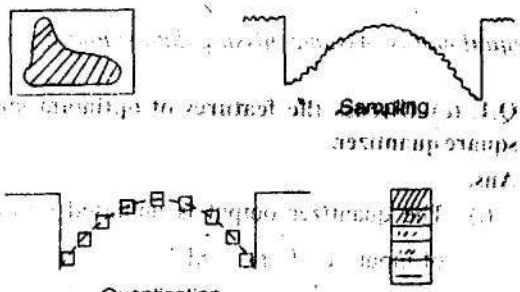

Fig. 2. Quantization

Q.1. (f) Enumerate the main features of median filter.

Ans. The averaging filter removes the noise by blurring it till its no longer seen. But its the process it also blurs the edges. Bigger the averaging mask, more is the blurring. When image contains salt and pepper noise, we can't use averaging filter. It can be used by non-linear filter, also called median filter.

In median filtering, gray level of centre pixel is removed and is replaced by median value from the neighbourhood. It preserves the edges and blurs the noise.

eg. {2, 3, 4, (3) 4, 5, 6}

{2, 3, 3, (4), 4, 5, 6}

Median

∴ **Ans.** {2, 3, 4, 4, 4, 5, 6}

2. Attempt any two parts of the following: **(10×2=20)**

Q.2. (a) What do you mean by colour space ? Classify them and describe CMY colour model.

Ans. Colour models are also called colour space. Colour models are different ways in which colour information is stored. There are various models that are used to stored various information regarding colour.

Classification of colour models are:

(*i*) RGB Colour Model

(*ii*) NTSC Colour Model

(*iii*) YC_bC_r Colour Model

(*iv*) CMY or CMYK Colour Model

(*v*) HSI Colour Model

C = Cyan; *M* = Magenta; *Y* = Yellow; *K* = Black. *CMY* are secondary colours of light.

Offset printing, digital printing and photographic prints are based on *CMYK* model.

C, *M*, *Y* mix to form black.

Transformation:

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Here *R*, *G*, *B* values are assumed to be normalized.

This equation simply means that light reflected from a surface coated with cyan pigment does not contain red. Similarly light reflected from surfaces coated with magenta and yellow pigments do not contain green and blue light respectively.

This is *CMYK* model.

Q.2. (b) How colour image filtering can be performed? Draw their block diagram and explain.

Ans. Colour image filtering can be performed in 2 ways:

(*i*) Colour image Smoothing (Low Pass Averaging)

(*ii*) Colour Image Sharpening (High Pass Filtering).

Colour Image Smoothing: A 3 × 3 mark to implement averaging

$$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

This concept can be extended to colour images

$$\bar{C}(x, y) = \frac{1}{K} \sum_{(x, y) \in S_{xy}} C(x, y)$$

Here, S_{xy} is neighbourhood.

$\bar{C}(x, y)$ is modified image and $C(x, y)$ is original image.

$$C(x,y) = \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \end{bmatrix}$$

$$\bar{C}(x,y) = \begin{bmatrix} \frac{1}{K}\sum_{(x,y)\in S_{xy}} R(x,y) \\ \frac{1}{K}\sum_{(x,y)\in S_{xy}} G(x,y) \\ \frac{1}{K}\sum_{(x,y)\in S_{xy}} B(x,y) \end{bmatrix}$$

Colour Image Sharpening: We use Laplacian operator for colour image sharpening.

$$\nabla^2[C(x,y)] = \begin{bmatrix} \nabla^2 R(x,y) \\ \nabla^2 G(x,y) \\ \nabla^2 B(x,y) \end{bmatrix}$$

We can use the Laplacian operator

0	−1	0
−1	4	−1
0	−1	0

If we want to preserve the low frequency, we can use the following mask:

0	−1	0
−1	5	−1
0	−1	0

i.e. Sum of coefficients ≠ 0

Q.2. (c) What do you mean by Gamma correction ? Draw the flow chart of Gamma correction and explain it.

Ans. Gamma correction, gammas non-linearity, gamma encoding or simply gamma is name of non-linear operation used to code and decode luminance or tristimulus values in video or still image systems. Gamma correction is, in simplest cases, defined by following power-law expression.

$$\{\text{text (out)}\} = \{\text{text (in)}\} \wedge \{1/\text{gamma}\}$$

Where input and output values are non-negative real values typically in predetermined range. Such as 0 or 1. A $\delta < 1$ is sometimes called an encoding gamma and process of encoding with this compressive power law non-linearity is called gamma compression; conversely a gamma value $\delta > 1$ is called decoding gamma and the application of expansive power-law non-linear is called gamma expansion.

An important characteristic of an image is its contrast, and by using gamma, contrast can be given a value. When photographic film is exposed to light, result of exposure can be shown on graph showing log of exposure on horizontal axis and density, or log of transmittance on vertical axis.

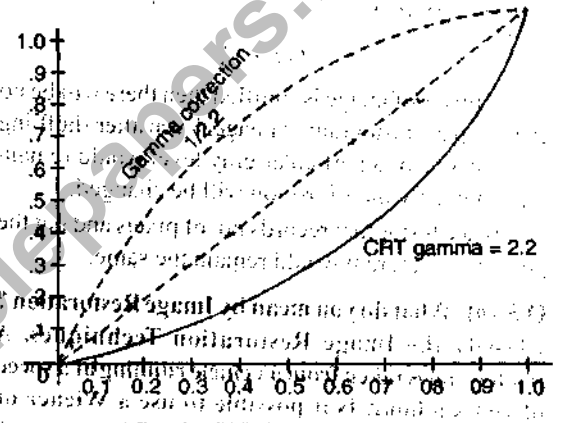

Fig. 2. CRT Gamma correction

3. Attempt any two parts of the following: (10×2=20)

Q.3. (a) What do you mean by Histogram ? Explain histogram equalization. If the pixels of an image is shuffled, will thereby any charge in the Histogram of image ? Justify your answer.

Ans. Histogram of images provide a global description of appearance of an image. The information obtained from histograms are enormous and hence its widely used.

By definition, histogram of an image represents the relative frequency of occurrence of various gray levels of an image. It can be drawn in 2 ways:

(*i*) *x* axis → gray levels
y axis → no. of pixels in each gray level

(*ii*) *x* axis → gray levels
y axis → probability of occurrence of gray level

Histogram Equalization: We know a perfect image is one which has equal no. of pixels in all of its gray levels. Hence our objective is not only to spread the dynamic range but to have equal pixels in all of its gray levels. This technique is called *histogram equalization.*

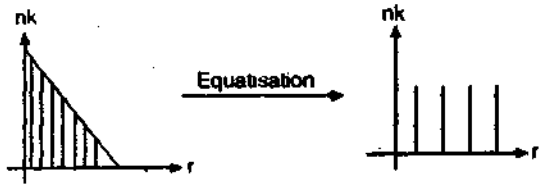

Fig. 4.

If pixels of image is shuffled then there will be no change in the histogram of image. Even after shuffling no. of pixels of a particular gray level would remain the same, only their position will be changed.

Since histogram records no. of pixels and not the position, histogram would remain the same.

Q.3. (*b*) What do you mean by Image Restoration ? Classify the Image Restoration Techniques. A photogram is taken from a vehicle running at a speed of 100 km/hour. Is it possible to use a Wiener or inverse filter to restore the blurring of the image ?

Ans. Image restoration can be defined as process of removal or reduction of degradation is an image through linear or non-linear filtering.

The aim of image restoration is to bring image towards what it would have been if it had been recorded without degradation.

Degradation Model: In Inverse filtering; we can remove blurs:

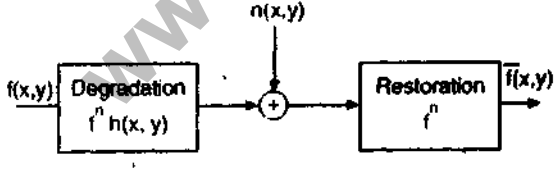

Fig. 5.

We know that input image $f(x, y)$ gets convolved by a blurring function $h(x, y)$ and changes to $g(x, y)$ hence to retrieve $f(x, y)$ from $g(x, y)$ we take inverse of $h(x, y)$.

$$g(x, y) = \sum_{k} \sum_{l} h(x-k, y-l) + (k, l)$$

[noise = 0]

Take Fourier transform:

$$G(u, v) = H(u, v) \times F(u, v)$$

$$\therefore \quad F(u, v) = \frac{G(u, v)}{H(u, v)}$$

$$\text{Let} \quad H_1(u, v) = \frac{1}{H(u, v)}$$

$\therefore$ Inverse filtering is given by:

$$F(u, v) = H_1(u, v) \times G(u, v)$$

Taking inverse Fourier transform:

$$f(x, y) = h_1(x, y) * g(x, y)$$

$\therefore$ Noise is removed.

Q.3. (*c*) What do you mean by image segmentation ? What are different approaches for image segmentation ? What are different methods for edge detection. Explain at least one method.

Ans. Image segmentation is the first step towards producing the description on an input image. Output is an abstract representation of the input. It divides the spatial domain on which the image is defined, into 'meaningful' parts or regions. Segmentation algorithm makes systematic use and physically measured image feature to extract regions. Segmentation approaches are based are:

(*i*) Discontinuity

(*ii*) Similarity

- Edge based segmentations is the principal approach used in discontinuity category.
- Region based segmentation are based are partitioning on image into regions that are similar according to set of predefined criteria.

Region growing segmentation has a seed pixel and by examining the nearest neighbouring pixels of the seed pixel one by one belong to the same region if they satisfy the homogeneity property of a regions.

Different approaches for edge detection are:

(*a*) Pattern fitting approach: Also called as edge filters. Here, a gray scale image is considered topographic surface where attitude at a point is given by its intensity or going level. The main objective is to fit a pattern over the neighbourhood of pixel at which strength is being calculated.

Example: Best plane fit gradient filters (bpf) method.

(b) Morphological edge detection: If a simple method of performing gray scale edge detection by using morphological operator. It takes the difference between an image and its chosen and dilation image of a structuring element.

The difference image obtained is an image of edge strength.

$$A-(A \oplus B) \quad \text{or} \quad A-(A(-)B)$$

4. Attempt any two parts of the following: **(10×2=20)**

Q.4. (a) Draw the block diagram of object recognition system and classify the object recognition system. Discuss non-parametric method of object recognition.

Ans.

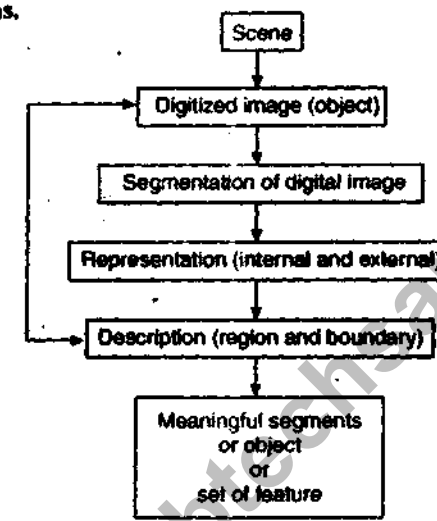

Fig. 6.

Object recognition is the process of identifying an object by the computer vision. It is the analysis of the input image to extract the useful segment, getting their description for object identification.

A non-parametric method are of 2 types:

(*i*) that do not rely on any particular distribution

(*ii*) that do not assume that the structure of a model is fixed. The model grows in size to accommodate the complexity of the data.

Thus, non-parametric method of object recognition do not depend on any pre-defined criteria and grows to identity an object by accommodating the complexity of data.

Object Recognition systems can be classified as the one based on pattern recognition, other on statistical approach and unsurprised classification and syntactic recognition technique when an object represented by features providing a powerful method for describing a large set of complex pattern recognition problems and a simple prevention and of grammatical rules that are recessive in nature. The technique is adopted from formal language theory and is called as linguistic approach.

Q.4. (b) Compare Template matching and Statistical method for image recognition. Explain any one method for image classification/recognitions.

Ans. Statistical Recognition: Suppose that one wants to distinguish football players and jockeys by their physical characteristic. Height would be one characteristic, and by itself would probably be a discussion nation.

For football and basket ball players, height out be the sole criteria weight is added to the discussion. If we add a sampling of jockeys, football and basketball players along axes of height and weight the jockeys would be clustered down the low height, low weight section, the football players in high weight, high height section and basketball in the fallen than football and slightly less than football in weight section.

Even if we can't perfectly make reasonable guesser based on these statistical properties.

This was statistical fallen recognition.

Pattern template recognition is the process whereby an unknown object within an image is identified as belonging to the particular group from among a number of possible object groups.

Classification includes a broad range of decision theoretic approaches to identification of images (or parts).

The classes may be specified period by an analyst or automatically clustered into sets of prototype classes, where the analyst merely specifies the number of desired categories.

Classification, segmentation have closely evaluated objectives.

Computer version and machine leaving as based on pattern classification.

Q.4. (c) Describe the techniques of edge and line detection.

Ans. Edge pixels or edges are detected by taking derivative followed by threshold up (*e.g.* Roberts operator, and 4-neighbour operator).

They are also used in noise removal as noise where as edge. (*e.g.* Prewitt operators and sobel operator). 2 dimensional derivative are computed by means of $n \times n$ matrix called as edge mask or operator.

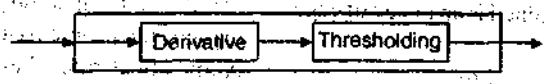

Fig. 7.

Derivative operators or difference operation in discrete domain yield high value at places where gray level changes rapidly. They are used to find gradient of an image.

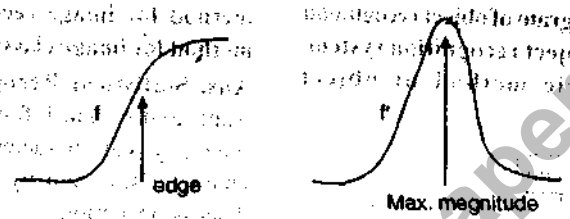

Fig. 8.

Hence, the gradient of image $g'(x, y)$ can be obtained from image $g(x, y)$ by transformation function

$$g'(x, y) = \nabla g(x, y)$$

Pattern Matching / Fitting approach: (edge filters): A gray scale image is considered a topographic surface where altitude at a point is given by its intensity or gray level. It is to fit a pattern over the neighbourhood of pixel at which edge strength is being calculated.

Morphological edge detection: Performing gray scale edge detection by using morphological operator. It takes the difference between an image and its erosion / dilation image by a structuring element.

Three main line detection operators are:

(*i*) Linear: These are pattern templates with suitable coefficients. *e.g.*,

-1/2	1	1/2
-1/2	1	1/2
-1/2	1	1/2

Vertical

-1/2	-1/2	1/2
1	1	1
1/2	1/2	1/2

Horizontal

1	-1/2	-1/2
1/2	1	-1/2
1/2	1/2	1

Left Diagram

-1/2	-1/2	1
-1/2	1	1/2
1	1/2	1/2

Right Diagram

(*ii*) Non-linear: Sensitive only where lines are very clear:

$$hv = (g_3 + g_0 + g_7) - 1/2\ \{g_2 + g_1 + g_4 + g_5 + g_6\}$$

$$g_7 > \{g_8, g_6\}\ g_0 > \{g_9, g_5\}\ g_3 > \{g_2, g_4\}$$

else $hv = 0$

(*iii*) Semi-linear: To overcome sensitivity problem.

$$hv = (g_3 + g_0 + g_7) - \frac{1}{2}\{g_2 + g_1 + g_4 + g_5 + g_6\}$$

$$(g_8 + g_7 + g_6) < (g_1 + g_0 + g_5)$$

$$(g_2 + g_1 + g_4) < (g_1 + g_0 + g_4)$$

5. Write short notes on any four parts of the following: **(5×4=20)**

(*a*) Feature Extraction

(*b*) Unsupervised Classification

(*c*) Object Recognition

(*d*) Decision Trees

(*e*) Graph Matching

(*f*) Composite Filters.

Ans. (*a*) Feature Extraction: It is also called Description. It deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another. The next step after representation is to discrete the regions based on the chosen representation.

For egs: A region may be represented by its boundary and the boundary described by features such as its length, the orientation of the straight line joining its extreme points and be nuclear of concavities in the boundary.

The features selected as descriptions should be as sensitive as possible to variations in syl, translation and rotation.

Transforming input data into the set of features is fracture extraction.

(*b*) Unsupervised classification: Clustering is an unsupervised method for classification. Using a similarity measure (*e.g.*, the dot product of 2 vectors, the weighted fucledian distance). The input vectors can be partitioned into subset/edge of which should be sufficiently distinct subsets which do not meet this criterion are merge. This process is repeated on all of the subsets until no splitting occurs, or the stopping criterion is meet.

The basic objective is to divide the data points of the feature space into a number of groups so that a predefined set of criteria are satisfied.

Criteria usually include the inter-class and inter class distance, density point within class, etc.

Object Recognition: Object recognition in computer version is the task of funding a given object in an image or video sequence. Humans recognize a multitude of objects in images with little efforts, despite the fact that the image of the objects may vary somewhat in different view points.

There are various methods for object identification or recognition.

(*i*) Appearance based methods

(*ii*) Feature based methods

(*iii*) Template matching, gradient histograms, etc.

Object recognition methods have various applications:

(*a*) Image Kamoramas

(*b*) Image water marking

(*c*) Global robot localization

(*d*) Face detection

(*e*) Optical character recognition

(*f*) Content based image indexing.

(*d*) Decision Trees: A decision tree is a decision support tool that uses a tree like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs and utility.

It is one way to display an algorithm. These are commonly used in operations research, in decision analysis to help identify a strategy most likely to reach a goal.

It is used for calculating conditional probabilities.

A decision tree consists of 3 types of nodes:

1. Decision nodes
2. Chance nodes
3. End nodes

(e) Graph matching: Here in this algorithm, edge pixel are represented as graph using edge chain. Starting with edge pixel '*P*' graph is searched for next pixel such that the over all cost $[\phi(n_k)]$ of reaching to another pixel *q* is optimized.

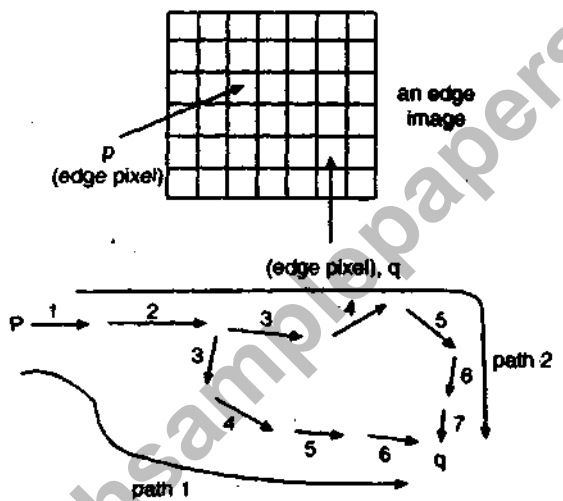

Fig. 9.

Path 1 is less costly in term of distance then Path 2.

(f) Composite filter: A composite image filter is an electronic filter consisting of multiple image filter sections of 2 or more different types.

The image method of filter design determines the properties of filter section by calculating the properties they have in an infinite chain of such sections.

Co-relation based pattern recognition has been an area of extensive search in past. Composite non-linear calculation filters invariants boislation, rotation and scale are proposed. Design is based on logical operators and non-linear co-relation. Performance of these non-linear co-relation filters is compared in terms of discrimination capability to other composite co-relation filters.