

UNIT III
IMAGE RESTORATION AND SEGMENTATION

Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering

Segmentation: Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation- Morphological processing- erosion and dilation.

PART - A

1. Mention two drawbacks of inverse filter. [Nov/Dec 2017]

- It is not always possible to obtain an inverse. For an inverse to exist, the matrix should be non-singular. In such case, **pseudo-inverse filter** can be used.
- Inverse filter will not perform well in the presence of noise. As the inverse filter will tend to amplify noise which is undesirable. In such case, **Wiener filter** can be used.

2. Which filter will be effective in minimizing the impact of "salt and pepper" noise in an image? [Nov/Dec 2017]

Median filtering is effective in minimizing the impact of salt and pepper noise in an image.

3. Why the restoration is called as unconstrained restoration? [Apr/May 2017]

In the absence of any knowledge about the noise 'n', a meaningful criterion function is to seek an f such that Hf approximates in a least square sense by assuming the noise term as small as possible. Where H - system operator, F - estimated input image and g - degraded image.

4. Define region growing. [Apr/May 2017, Nov/Dec 2015]

Region growing is a procedure that groups pixels or sub regions into layer regions based on predefined criteria. The basic approach is to start with a set of seed points and from there grow regions by appending to each seed the neighboring pixels that have properties similar to the seed.

5. State the causes of degradation in an image. [Nov/Dec 2016]

The degradations may be in the form of

- Sensor noise
- Blur due to camera misfocus
- Relative object-camera motion(motion blur)
- Random atmospheric turbulence.

6. What do you understand by Mexican hat function or LoG? [Nov/Dec 2016]

To overcome the disadvantages of laplacian operator it is combined with smoothing as precursor to find edges via zero crossings. Due to its shape, LoG (Laplacian of Gaussian) is sometimes called as Mexican hat function. A Mexican hat function based operator is used for image feature detection, including the local area detection and the feature point detection.

7. When will a constrained least square filter (CLS) reduce to an inverse filter? [May/June 2016]

The frequency domain representation of a constrained least square filter is given by,

$$\hat{F}(k, l) = \left[\frac{H^*(k, l)}{|H(k, l)|^2 + \lambda |P(k, l)|^2} \right] G(k, l)$$

If P(k,l) is zero, then

$$\hat{F}(k, l) = \frac{1}{H(k, l)}$$

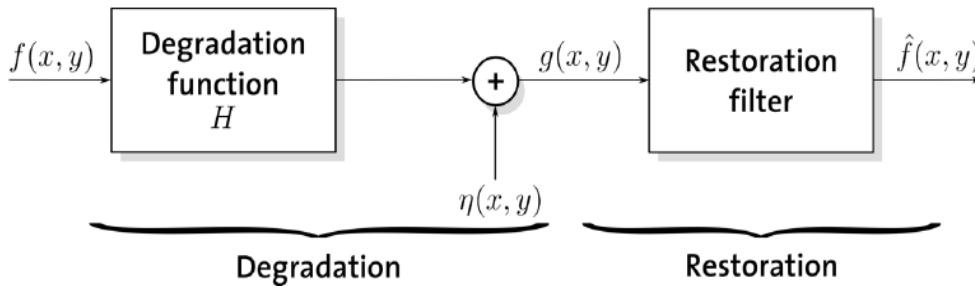
8. Give two applications of image segmentation. [May/June 2016]

Segmentation is the foremost step for all the detection and recognition applications. The applications of segmentation are,

- i. Detection of cancerous cells from medical images
- ii. Segmentation of roads from satellite images
- iii. Vehicle Number Plate recognition
- iv. Handwritten character recognition

9. How a degradation process is modeled? [MAY/JUN 2013/2015]

The Image degradation/ restoration model is given as,



Degradation:

A system operator H (degradation function), together with an additive white noise term $\eta(x,y)$ operates on an input image $f(x,y)$ to produce a degraded image $g(x,y)$.

Restoration

The restoration filter which is inverse of the degradation function is used to obtain an estimate of the original image from the degraded image.

10. Differentiate image enhancement and image restoration. [NOV/DEC 2015]

S.No.	Image Enhancement	Image Restoration
1.	Image enhancement is a subjective process i.e., it is a heuristic procedure designed to manipulate an image in order to please the viewer.	Restoration techniques are oriented towards modeling the degradation and applying the inverse process in order to recover the original image.
2.	Modeling of degradation process is not required.	Modeling of degradation is a must.
3.	Apriori knowledge of the degradation is not required. Ex: Contrast stretching	Apriori knowledge of the degradation function is required to model the degradation function. Ex: Removal of motion blur

11. What is thresholding? What are its types? [NOV/DEC 2015]

Thresholding is the process of segmenting an image based on a threshold value that separates the object and background of the image. Certain images will contain multiple objects, which can be segmented using multiple thresholds. The types of thresholding are

- Global Thresholding

- Variable Thresholding
- Regional (or) Local Thresholding
- Dynamic or Adaptive thresholding

12. What is meant by Image Restoration?

Restoration attempts to reconstruct or recover an image that has been degraded, by using a clear knowledge of the degrading phenomenon.

13. What are the types of noise models?

- i. Gaussian noise
- ii. Rayleigh noise
- iii. Erlang noise
- iv. Exponential noise
- v. Uniform noise
- vi. Impulse noise

14. What is salt and pepper noise? Suggest a filter to remove salt and pepper noise in images.

Bipolar impulse noise is called as Salt and Pepper Noise. Median filter is the most suitable filter to remove salt and pepper noise in images.

15. What is periodic noise?

Periodic noise arises typically from electrical or electromechanical interference during image acquisition.

16. What is Fredholm integral of first kind?

The equation,

$$g(x, y) = \int_{-\infty}^{+\infty} f(\alpha, \beta) h(x, \alpha, y, \beta) d\alpha d\beta$$

which is called the superposition or convolution or Fredholm integral of first kind. It states that if the response of H to an impulse is known, the response to any input $f(\alpha, \beta)$ can be calculated by means of Fredholm integral.

17. What is a Median filter? What are its properties?

The median filter replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel. Median filter has the following properties:

- i) A median filter smoothens additive white noise
- ii) A median filter does not degrade edges
- iii) A median filter is effective in removing impulses. (Salt and pepper noise).

18. What is maximum filter and minimum filter?

The 100th percentile is maximum filter, that is a Max filter replaces the value of a pixel by the maximum value of the gray levels in the neighborhood of that pixel. It is used in finding brightest points in an image and is effective in removing pepper noise.

The 0th percentile filter is minimum filter, that is a Min filter replaces the value of a pixel by the minimum value of the gray levels in the neighborhood of that pixel. It is used in finding darkest points in an image and is effective in removing salt noise.

19. What is geometric mean filtering?

Geometric mean filter achieves smoothing better than the arithmetic mean filter. The amount of details lost in the geometric mean filtering is lesser. The filter is given by,

$$\hat{f}(x, y) = \left[\prod_{(s,t) \in S_{xy}} g(s, t) \right]^{\frac{1}{mn}}$$

The product of the pixel values in the defined neighborhood raised to the power of $1/mn$, gives the restore pixel value.

20. Mention the need for adaptive median filter.

Though median filter is effective in removing impulse noise, the fine details in the image are lost since the impulses are replaced with median values. Thus adaptive median filters are used to overcome this disadvantage of median filter.

21. What are the filters that can be used to remove periodic noise?

Frequency domain filters are to be used to remove periodic noise in images.

The commonly used frequency domain filters are,

- Notch Filters
 - Notch Reject filters
 - Notch Pass filters
- Optimum notch filters

22. Is 100% restoration possible. Justify.

100% restoration is possible only if the true degradation function is known and the image is degraded only due to this degradation function. If the image is degraded by additive noise, 100% restoration is not possible.

23. What are the commonly used image restoration filters?

Commonly used restoration filters are, i) Inverse Filter ii) Wiener Filter iii) Pseudo Inverse Filter.

24. What is inverse filtering?

The simplest approach to restoration is direct inverse filtering, an estimate $F^{\wedge}(U,V)$ of the transform of the original image simply by dividing the transform of the degraded image $G(U,V)$ by the degradation function.

$$F^{\wedge}(U,V) = G(U,V)/H(U,V)$$

25. What is meant by blind image restoration?

The process of restoring an image whose true degradation function is not known completely is called blind deconvolution or blind image restoration.

26. What are the disadvantage of wiener filter?

- i) Some knowledge of the degradation function is required
- ii) Power spectra of the undegraded image and noise must be known.

27. What is segmentation?

Segmentation subdivides an image into its constituent regions or objects. The level to which the subdivision is carried depends on the problem being solved. That is segmentation should stop when the objects of interest in application have been isolated.

28. How are edges detected in images?

Derivatives are used to detect the edges in images.

- First order derivative filters are used to detect the presence of edge. Examples are
 - Robert's Cross Gradient Operator
 - Prewitt's Operator
 - Sobel's Operator
- Second order derivative filters are used to detect the thin edges that is the fine details in the image. Example: Laplacian

29. Write about linking edge points.

The approach for linking edge points is to analyze the characteristics of pixels in a small neighborhood (3x3 or 5x5) about every point (x,y) in an image that has undergone edge detection. All points that are similar are linked, forming a boundary of pixels that share some common properties.

30. What are the two properties used for establishing similarity of edge pixels?

- (i) The strength of the response of the gradient operator used to produce the edge pixel.
- (ii) The direction of the gradient.

31. What is edge? What are its types?

An edge is a set of connected pixels that lie on the boundary between two regions. The types of edges are

- Ideal Edge
- Ramp Edge
- Line Edge
- Roof Edge

32. Give the properties of the second order derivative around an edge.

- The sign of the second order derivative can be used to determine whether an edge pixel lies on the dark or light side of an edge.
- It produces two values for every edge in an image.
- An imaginary straight line joining the extreme positive and negative values of the second derivative would cross zero near the midpoint of the edge.

33. What is meant by zero crossing property of second order derivative?

An imaginary line joining the extreme positive and negative values of the second derivative would cross zero near the midpoint of the edge. This property is called zero crossing property and is used for locating the centre of thick edges.

34. What are the disadvantages of Laplacian operator?

- It is very sensitive to noise.
- Magnitude of Laplacian produces double edges, hence it complicates segmentation.
- Laplacian is unable to detect edge direction.

35. What are the various techniques that can be used for edge linking?

- i. Local Processing
- ii. Global Processing via Hough Transform
- iii. Global Processing via Graph Theoretic Techniques.

36. What is object point and background point?

For any image $f(x,y)$ if we analyze the histogram of the image we find that object and background pixels have gray levels grouped into two dominant modes. To segment the objects from the background select a threshold T that separate these modes. Then any point (x,y) for which $f(x,y) > T$ is called an object point. Otherwise the point is called background point.

37. What are the disadvantages of thresholding?

- Only two classes (object, background) are generated hence cannot be applied to multi-channel images.
- More sensitive to noise.
- Requires the input image to have homogenous intensity.

38. Specify the steps involved in splitting and merging.

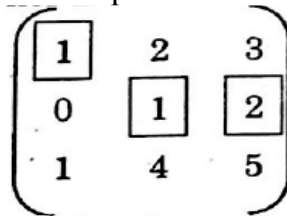
- i. Split any region R_i into 4 disjoint quadrants for which $P(R_i) = \text{FALSE}$.
- ii. Merge any adjacent regions R_j and R_k for which $P(R_j \cup R_k) = \text{TRUE}$.
- iii. Stop when no further merging or splitting is possible.

39. What is a quadtree?

Quadtree is a tree in which each node have exactly four descendants.

PART – B**Image Restoration**

1. Draw the block diagram for image degradation model and explain. [May/June 2016]
2. Apply order statistics filters on the selected pixels in the image. [Nov/Dec 2016]



3. Describe the image restoration technique of inverse filtering. Why inverse filtering approach fails in the presence of noise? [May/June 2014, May/June 2015, Nov/Dec 2017]
4. Derive a Wiener filter for image restoration and specify its advantages over inverse filter. [Apr/May 2017]
5. Explain how wiener filter is used for image restoration. [Nov/Dec 2013, May/June 2014, May/June 2016, Nov/Dec 2016]

Image Segmentation

1. What is the objective of image segmentation? Explain any one of the region based image segmentation technique in detail. Mention two applications of image segmentation. [Nov/Dec 2017]
2. Explain region splitting and merging technique for image segmentation with suitable examples. [Apr/May 2017]
3. a) Explain the process of edge linking using Hough transform. [Nov/Dec 2015, Nov/Dec 2016]
b) Explain region based segmentation techniques. [Nov/Dec 2016]
4. Define thresholding and explain the various methods of thresholding in detail? [Nov/Dec 2013]