Date

② Colors Models :

- RGB (RED, GREEN, B~~Ø~~LUE) Model :
- RGB is a color model used in digital imaging and computer graphics
- In this model colors are represented as combinations of red, green and blue light.
- Each color is described by three intensity value usually ranging from 0 to 255.

- CMY (Cyan, Magenta, Yellow) Model :
- CMY used in color printing and mixing pigments
- The combination of these three subtractive primary colors can create wide range of colors by absording (subtracting) different wavelengths of light.

- CMYK (Cyan, Magenta, Yellow, Black) Model :
- The addition of Black (K) is to improve the depth of black tones and save the amount of ink used when printing black.
- The "K" stands for "Key" a term used in printing industry for Black plate.

HSI (Hue , Saturation , Intensity) Model :

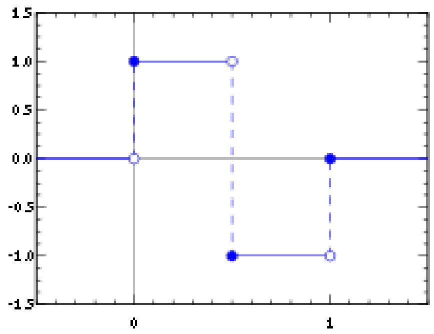
- The HSI color model represents colors based on three components :

1. Hue (H) : Type of color on the color wheel.
2. Saturation (S) : Purity or vividness of the color.
3. Intensity (I) : Brightness or Intensity of the colo

- It seperates color information from intensity, making it useful in tasks like color manipulation and analysis in image processing

Unit-3

HAAR



- **Haar Transform Process**
  - To perform the Haar transform, x takes discrete values at m/N, where m = 0, 1,..., N-1.
  - Haar transform is defined for N = 8.
- **Properties of the Haar Transform**
  1. The Haar transform is real and orthogonal, denoted as Hr=Hr* and Hr-1 = Hr^T.
  2. In computing, the Haar transform is exceptionally fast, requiring O(N) operations for an N x 1 vector.
  3. Basis vectors of the Haar matrix are ordered in a frequency-ordered manner.
  4. For images, the energy compaction of the Haar transform is weak.

What is wavelets transform ? What are the types of wavelets transform.

- 1 Wavelets are mathematical function that splits the data into frequency components and then study & process each components with resolution matched to its scales.
- 2 Wavelets transform decomposes a signal into set of basis function.
- 3 These basis function is known as wavelets.

There are some types of wavelets transform, they are as follows:

- **Continous Wavelets Transform :** It is a powerful matthmatical tool used for analyzing signal and extracting information from them.

- **Haar Wavelete Transform :** It seperates the image into high frequency and low frequency components.

- **Fast wavelets Transform :** It utilizes algorithm for faster computation of wavelets transform.

- **Discrete wavelet Transform :** It is a technique to transform image pixels into wavelets which are then used for wavelets based compression & coding.

Compression Techniques: Lossless And Lossy.

1. Lossless Compression:

• **Purpose:** Maintains all the original data after compression.
• **Techniques:** Run-Length Encoding (RLE), Huffman Coding, and Lempel-Ziv-Welch (LZW) are common algorithms.
• **Use Case:** Suitable for applications where exact reproduction of the original image is critical, such as medical imaging or text documents.

2. Lossy Compression:

• **Purpose:** Sacrifices some data to achieve higher compression ratios.
• **Techniques:** Discrete Cosine Transform (DCT), used in JPEG compression, and Wavelet-based compression, as seen in JPEG2000.
• **Use Case:** Commonly used in multimedia applications, such as web images and streaming, where a small loss in quality is acceptable.

*Watersheds Algorithm

The Watershed algorithm is a segmentation technique in image processing that is particularly useful for separating touching or overlapping objects in an image

1. Marker Placement:

Place markers at local minima, serving as starting points for flooding. - Identifies lowest points in the image.

2. Flooding:

- Algorithm floods the image from markers with different colors.
- Colors spread, filling catchment basins up to object boundaries.

3. Catchment Basin Formation:

- Color spreading fills catchment basins, creating image segmentation.
- Resulting segments are assigned unique colors for object identification.

4. Boundary Identification:

- Watershed algorithm uses boundaries between colored regions.
- Segmentation aids object recognition, image analysis, and feature extraction.

*Erosion And Dilation:

Erosion:

- It is shrinks the image pixel by removing pixel on the object boundary.
- The structure element Travers over the image object to perform Erosion.
- The output values are calculated using...
- Pixel (output) = 1 if Fit
  0 if Otherwise

  - **Properties of Erosion**
    - It can splits joints objects
    - It can get rid of extrusion

Dilation:

- It expanding a image pixel by adding pixel on the object boundary.
- The structural element Travers over the image object to perform dilation operation
- The artificial value is calculated using the following equation:
- Pixel (output) = 1 if Hit
  0 if Miss

  - **Properties of dilation**
    - It can repair break in image
    - It can repair Erosion in an image

*Types of Thresholding

- **Global Thresholding:**
  A single threshold value is applied to the entire image to separate pixels into foreground and background.
- **Local Thresholding:**
  Applies different threshold values to different regions of the image based on local characteristics.
- **Adaptive Thresholding:**
  Divides the image into smaller regions and applies different threshold values to each region based on local characteristics.
- **Using Otsu's Method:**
  Automatically calculates an optimal global threshold by minimizing the intra-class variance of pixel intensities.
- **Hysteresis Thresholding (Double Thresholding):**
  Uses two threshold values, a lower threshold and an upper threshold, to classify pixels as potential edges

*Segmentation

Few Types of Segmentation:

Thresholding: Thresholding is used to create binary images from a grayscale image
Divides an image into regions based on intensity levels or color values using a threshold

Region Growing: Starts with seed points and grows regions by adding neighboring pixels that have similar properties.

Edge Detection-Based: Identifies boundaries or edges in an image and segments based on changes in intensity or color gradients.

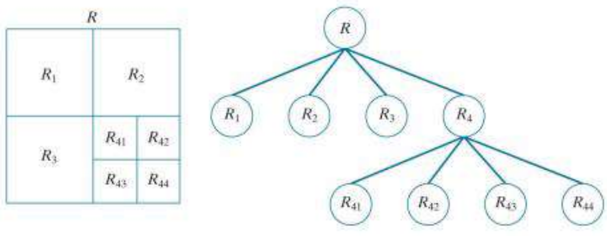
Watershed Segmentation: Treats pixel intensities as topography and simulates the flooding of basins to separate regions.

Clustering-Based: Groups pixels into clusters based on similarities in color, intensity, or feature space

Contour-Based: Identifies and follows contours or outlines of objects in an image.

*Region splitting

- **Region splitting**: Image segmentation technique based on pixel intensity variations.
- **Recursive approach**: Large regions successively subdivided into smaller ones.
- **Criteria-driven**: Subdivision continues until specific criteria are met, ensuring homogeneous and maximal regions.



1……….

A) Closing

A morphological operation that involves the dilation followed by erosion of an image to fill in gaps, smooth contours, and connect or close small breaks in object boundaries.

B) Opening

It is a morphological operation that consists of an erosion followed by a dilation, effectively removing small objects and smoothing the boundaries of larger objects in a binary or grayscale image.

C) Erosion

It is a morphological operation that removes fine details or boundaries from regions in a binary or grayscale image by applying a structuring element

D) Dilution

A morphological operation that expands the boundaries of regions in an image, often used for accentuating or enlarging features.

E) Hit or Miss

A morphological operation in image processing that identifies patterns in an image by combining the results of both erosion and complemented erosion with structuring elements.

F) Skeletonization

A process that reduces the representation of shapes in an image to their medial axes or skeletons, providing a simplified and thin representation of the structures.

G) Thickening

It is a morphological operation that enhances the boundaries and connectivity of regions in a binary image by adding pixels to the regions.

H) Thinning

Is the iterative removal of pixels along the object boundaries to reduce the width of the features, producing a skeletonized representation of the objects.

I) Pruning

The removal or reduction of certain components or features, often with the goal of simplifying or optimizing the representation of an image.

J) Convex Hull

It is the smallest convex polygon that encloses all foreground pixels in a binary image.

Q. Image Segmentation using Snakes

1. **Connectivity and Homogeneity:**
   - Image segmentation relies on connectivity and homogeneity based on image data, particularly challenging in medical image analysis due to anatomical complexities.
2. **Active Contours:**
   - Active contours, also known as "snakes," are crucial for segmentation, operating within an active contour framework where a closed contour evolves to minimize energy, making the snake dynamic.
3. **Energy Function:**
   - The energy function ($E_{snake} = E_{internal} + E_{external}$) of a snake involves internal properties (length, curvature) and external factors (image structure, user constraints), enabling effective segmentation.
4. **Advantages:**
   - Active contouring results in closed, coherent areas with smooth boundaries, enhancing segmentation accuracy.
5. **Semi-Automatic Process:**
   - Active contouring is semi-automatic, requiring user-defined initial contours for the process.
6. **Deformable Models:**
   - Deformable models, represented as curves or surfaces, move under internal and external forces within the image data, providing flexibility in segmentation.
7. **Problems with Snake Segmentation:**
   - Snakes may oversmooth boundaries.
   - Initialization is crucial for effective segmentation.
   - Dependence on the number and spacing of control points.
   - May not accurately follow topological changes in objects.

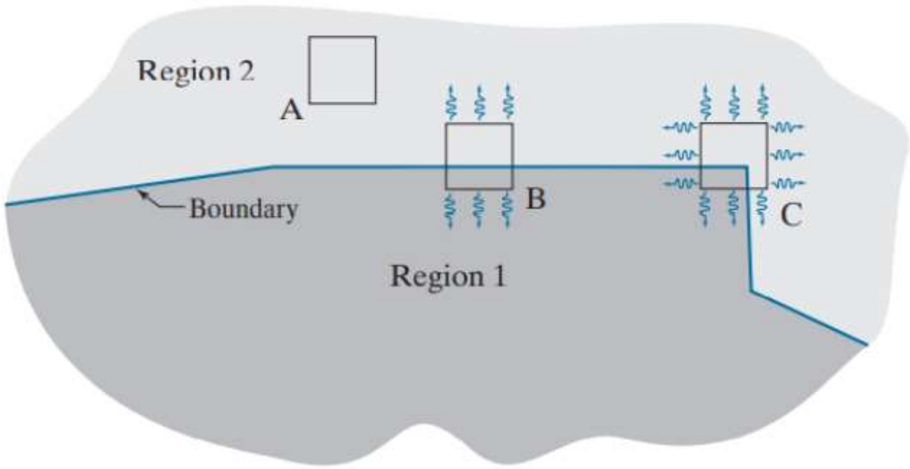
Image Segmentation using Level Sets

- **Level Set**: It is Alternative to closed contours.
- It Fits and tracks objects by modifying the embedding function instead of curve function.

Q. Scale Invariant Feature Transform (SIFT)

1. **Definition**: SIFT is a complex algorithm developed by Lowe [2004] for extracting invariant features from images.
2. **Transformation**: It transforms image data into scale-invariant coordinates relative to local features.
3. **Application**: SIFT is crucial for feature detection and description in the presence of scale changes, rotation, illumination variations, and viewpoint changes.
4. **Key Points**: SIFT features, known as key points, are invariant to image scale and rotation, robust to affine distortions, 3-D viewpoint changes, noise, and illumination variations.
5. **Input and Output**: Takes an image as input and produces an n-dimensional feature vector with invariant feature descriptors as output.
6. **Algorithm Stages**:
   i. **Scale Invariance**: Identifies image locations invariant to scale changes.
   ii. **Scale Space**: Utilizes Gaussian kernels for smoothing, with the scale parameter as the standard deviation.
   iii. **Octave Subdivision**: Divides scale space into octaves, doubling the standard deviation $\sigma\sigma$.
   iv. **Key Point Refinement**: Finds key points using Gaussian-filtered images, refining locations and validity.
   v. **Orientation and Descriptors**: Computes key point orientations and descriptors, improving accuracy and eliminating edge responses.

Q. Whole Image Features



- Principal feature detection involves corners and entire image regions.
- The Harris-Stephens Corner Detector is a key method.
  The basic approach is this: Corners are detected using a small window over
- an image.
- The detector is designed to compute intensity changes

➢ ***Three scenarios in corner detection:***

1. Constant Region (Location A): Zero or small intensity changes in all directions, indicating a constant or nearly constant region.

2. Region Boundary (Location B): Changes in one direction but no or small changes in the orthogonal direction, signifying a boundary between two regions.

3. Corner or Isolated Points (Location C):

- Significant changes in all directions, occurring when the window contains a corner or isolated points.
- The Harris Corner Detector (HS) is a mathematical formulation designed to differentiate between these conditions by analyzing image patches.
- Let f denote an image, and let f (s, t) denote a patch of the image defined by the values of (s, t). A patch of the same size, but shifted by (x, y), is given by f (s + x, t + y).

$$C(x,y) = \sum_s \sum_t w(s,t)\left[xf_x(s,t) + yf_y(s,t)\right]^2$$

The above equation can be written in the form

$$C(x,y) = [x \;\; y]\,\mathbf{M}\begin{bmatrix} x \\ y \end{bmatrix}$$

Where,

$$\mathbf{M} = \sum_s \sum_t w(s,t)\mathbf{A}$$

$$\mathbf{A} = \begin{bmatrix} f_x^2 & f_x f_y \\ f_x f_y & f_y^2 \end{bmatrix}$$

Matrix M is called as Harris matrix.