REVIEW OF IMAGE SEGMENTATION AND ITS TECHNIQUES

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Abstract – Nowadays, image segmentation is the most important process of digital image processing. It is used for image compression and object recognition to simplify it. Image segmentation partitions the image into segments based on their certain features such as color, texture, intensity values etc. These segments should be meaningful that can be easily analyze. It actually locates the objects and boundaries of an image. This paper reviews various region based and edge based segmentation techniques and their comparison. These techniques effectively segment the image in a meaningful way.
Keywords- Image segmentation, Region based and Edge based segmentation

I. INTRODUCTION

Image segmentation is one of the most important processes of digital image processing. Image segmentation is the method that subdivides an image into meaningful segments, having similar properties, attributes and features. It is used to locate the objects and boundaries such as lines and curves in images. It means, each and every pixel of an image is assigned with a label such that same labels of image pixels share common visual characteristics. The main aim of segmentation is to make the image's representation as simple as easy to understand by reducing the information of an image into meaningful way. Basically image segmentation is classified into two types: Local segmentation that referred to the specific region or part of the image and Global segmentation that concerned with the segmentation of the whole image (consisting of large number of pixels) [1].

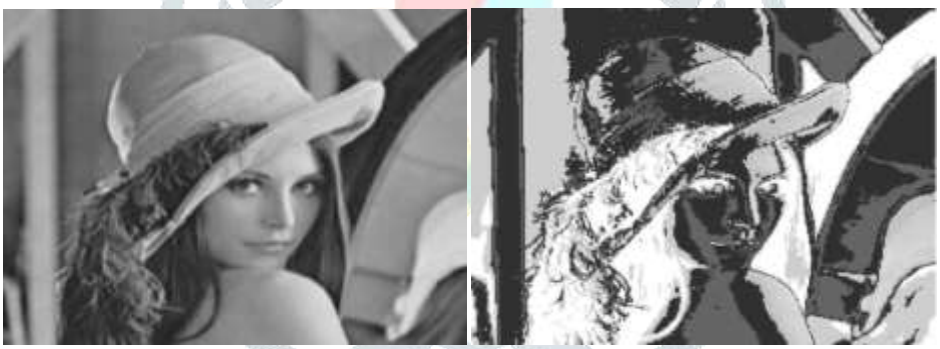

fig. 1. original image and segmented image

The process of image segmentation is subdividing an image into the constituent parts and each sub-part depends upon the problem being solved.[2] In image processing, image engineering presents the level of image segmentation that is divided into three levels that are: **Image processing** (low level) applied on image's pixel level and modifying it by reconstructing (removing and minimizing degradations of image), transforming (contrast stretching, noise filtering, histogram modification and compression of an image) and classification (segment an image then classifying it based on gray levels). **Image analysis** (middle level) focuses on measuring and generates a new set of an image from given set. **Image understanding** (high level) is further study and explanation of an original image. Image segmentation is the key step from the image processing to image analysis[3][4].

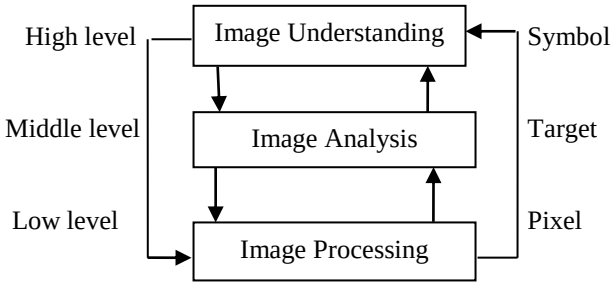

fig. 2. image engineering process

II. NEED AND APPLICATIONS OF IMAGE SEGMENTATION:

The main aim of image segmentation is easy to analyze or make the image more meaningful by changing its representation and easily understood. It is used to detect the objects and boundaries in an image such as lines, curves etc. Image segmentation is analysis process to identify the objects from the image.

Various applications of image segmentation are medical image processing such as detection and measurement of bone and tissues, biometrics, industrial inspection, and in satellite images to detect the roads and bridges etc.

III. IMAGE SEGMENTATION APPROACHES:

Image segmentation approaches are of two basic types that based on properties of an image[1][5].

Detecting Discontinuity: It means if there are sudden changes in gray level of an image then image is segmented. The basic principles areas of interest are: Detection of isolated points and Detection of lines and edges in images.

Detecting Similarity: Image is subdivided into regions that having similar set of pixels. It is based on Thresholding, Region growing, Region splitting and merging.

IV. CLASSIFICATION OF IMAGE SEGMENTATION TECHNIQUES:

Based on discontinuity and similarity approaches, the image segmentation techniques are classified into following two categories:[3]

1. **Layer-Based Segmentation Methods**: This method is used to evaluate the shape masks, detect an object and explain the appearance, depth and define both the class and instance segmentation.
2. **Block-Based Segmentation Methods:** These segmentation methods are based on various features such as information about image pixels that indicate edges or boundaries or texture information, or color information that is used to create histograms, found in the image. [5] [6]

Region based segmentation: In this method, entire image divided into sub regions or clusters based on the similarity such that the pixels with same grey level are grouped into one region.

Edge or boundary based segmentation: This method is based on the discontinuity in the intensity values of an image. This method is used to detect the edges of an image by changing the intensity values. There are three types of discontinuities in the gray level image. These are point, line and edges. Spatial masks are used to detect these discontinuities. [7] [8]

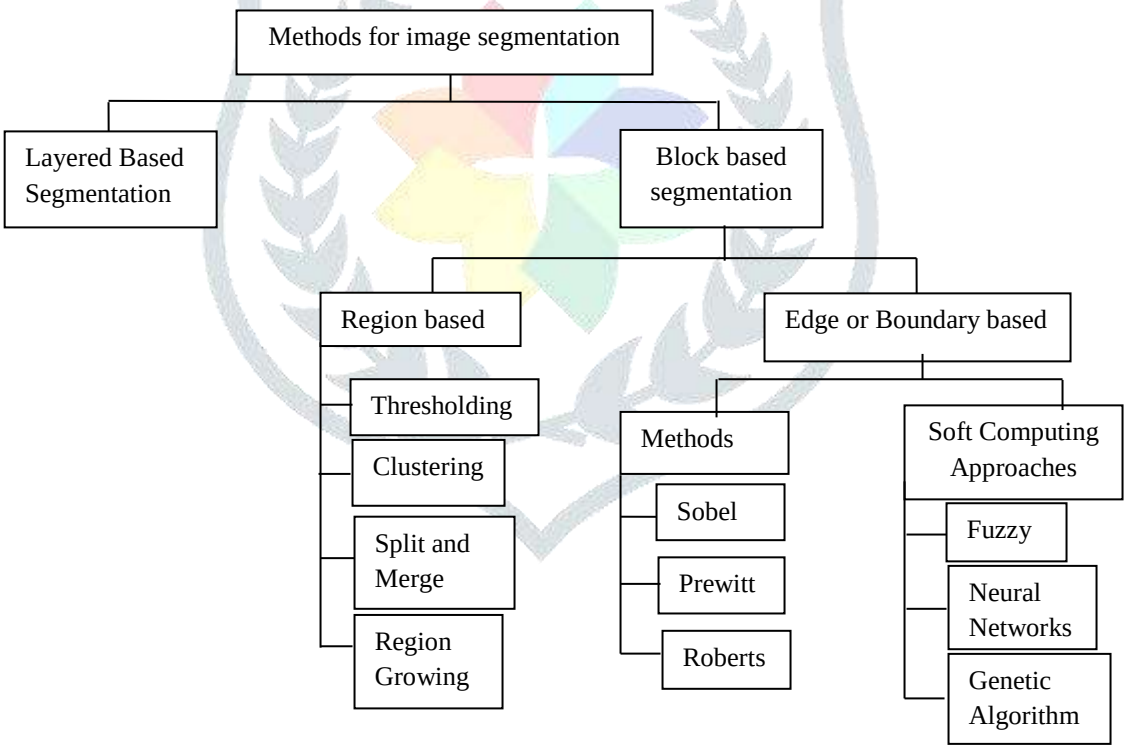

fig. 3. classification of image segmentation techniques

1. REGION BASED SEGMENTATION:

1.1 Thresholding

Thresholding is a basic fundamental step that applied on image for object representation, image analysis and visualization. This technique is used for partitioning the image pixels with respect to their intensity level i.e. in which a pixel lies according to the range of values, are allotted to the categories. It segmented the images that having lighter objects than background. It converts the multilevel image into binary image. The segmented region might be differ(either smaller or larger) from the actual image and the edges should not be connected[9].

fig. 4. original image and thresholded image

Thresholding is the simplest and widely used technique. The main aim of thresholding is to separate a foreground of the image from its background by selecting an appropriate threshold value of a gray scale image. It is used in many applications such as DNA analysis and detection, medical imaging, industrial inspection and tracking.

- Thresholding is viewed as an operation[10][11]:
  T=T[x,y, p(x,y), f(x,y)] ;where f(x,y) is the gray level of point (x,y) and p(x,y) is some local property of point.
- Thresholded image is given by

$$g(x,y)=\begin{cases}1 & \text{if } f(x,y)>T\\ 0 & \text{if } f(x,y)<=T\end{cases}$$

Pixels labeled as 1 or any other convenient gray level value correspond to objects.

- Thresholding can be of following categories[12]:

Global Thresholding: It uses a single threshold value to separate foreground from background of an image. The threshold T depends on the global properties of an image by obtaining the information from it e.g. by using image histogram, texture properties.

Local Thresholding: It is used to determine whether the pixel is foreground background using the local information of an image by assigning threshold value to each pixel. The threshold T depends on the local properties of the image pixels and their neighbourhoods.

Dynamic Thresholding: In addition, T depends on the spatial coordinates (x,y).

Multilevel Thresholding: This thresholding method is effectively applied when the image is complex and contains multiple objects. It is also used to segment an image by selecting appropriate values of thresholds. Otsu's method is used for optimizing the threshold values[13].

1.2 Clustering

It is the process of organizing the objects, which are similar in some sense, into groups or regions. All pixels in a region share a common property. [14]

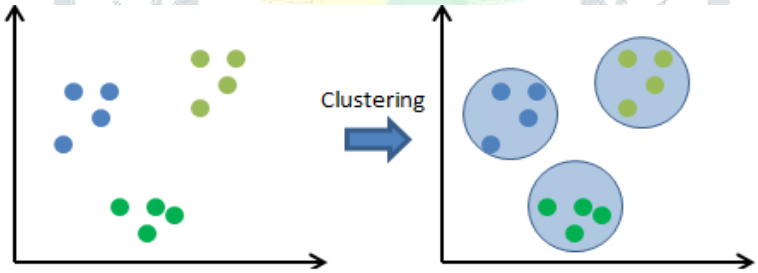

fig. 5. clustering

There are two types of clustering[1][14]:

Hard clustering: It is the simplest method of dividing the image into set of clusters such that each pixel belongs to exactly one cluster i.e. there is no overlapping of clusters (distinct clusters).

Soft clustering: It is most useful method of image segmentation in which one or more pixels of a cluster belong to other clusters. This method is more flexible than hard clustering.

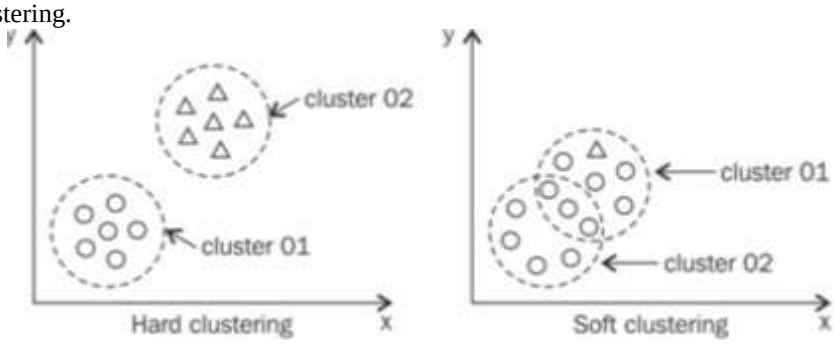

fig. 6. hard and soft clustering

K-means Clustering: K -means clustering algorithm is an unsupervised algorithm and it is used to segment the interest area from the background. A collection of data partitioned into a k number group of data and classifies a given set of data into k number of disjoint cluster. K-means clustering is used in medical images and security systems[15][16][17].

K-means algorithm:

1. Initialize number of cluster k and calculate the mean value.
2. Find the pixels that have the value nearest to the mean and assign to the cluster.
3. After assigning the pixels, the recalculate the mean.
4. Repeat the step 1 and 2 until it satisfy the error value.

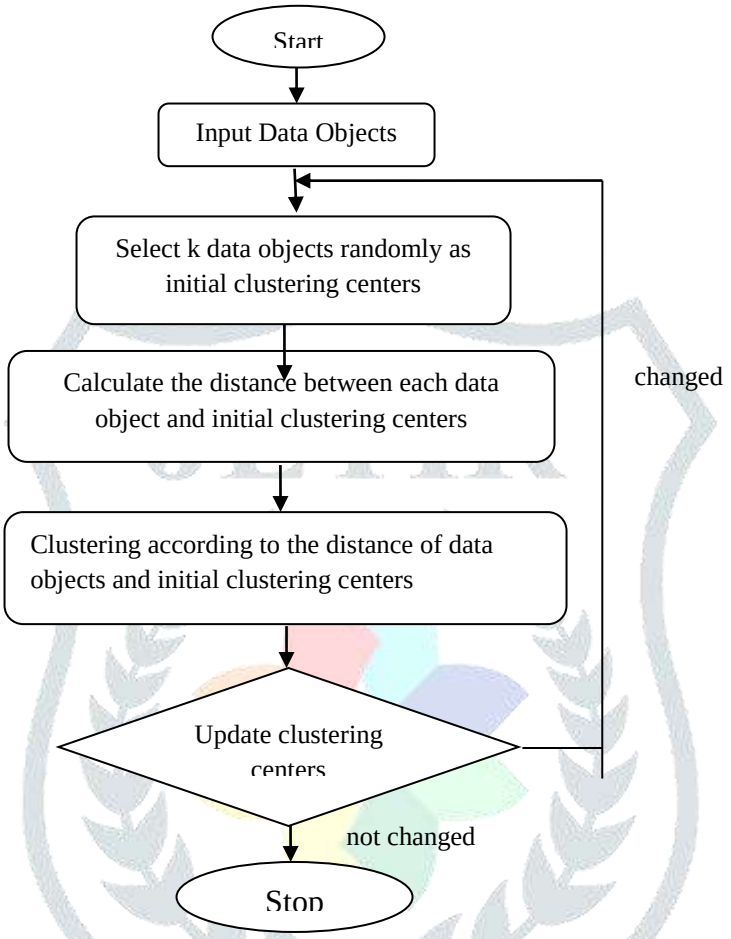

fig. 7. k-means flow chart

1.3 Split and Merge

It is the simplest method for segmenting an image. It needs a threshold value as an input. That threshold value describes which region need to be split further into small regions and which regions can be merged into single region. A single block of region is split repeatedly until there are no more splits possible. If these splits are similar then merge two or more regions and repeat this process until no more merging is possible.

An image is divided iteratively into regions with similar characteristics and merging the adjacent similar regions. Quad tree is a splitting data structure[3][9][18].

The basic algorithm steps for region growing and merging are[1]:

Let "p" be the original image and "T" be the particular predicate. First of all the R1 is equal to p.

- Each region is divided into quadrants for which T (Ri) = False.
- If for every region, T (Rj) = True, then merge adjacent regions Ri and Rj such that T (Ri U Rj) = True.
- Repeat step 3 until merging is impossible.

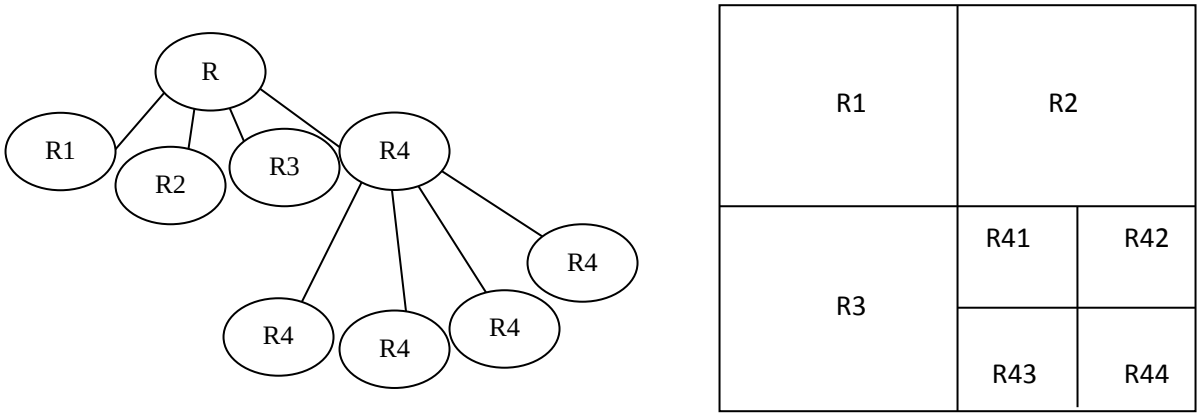

fig. 8. division of regions based on quad-tree

1.4 Region Growing Segmentation

It is one of the most important methods for the image segmentation. It begins with a pixel level and grouped together the pixels in the regions based on their similarity and repeat until all pixels belong to some region.

Based on the growing of seeds (initial pixels), region growing splits the image into various regions. These seeds can be selected manually (based on prior knowledge) or automatically (based on particular application). Then the connectivity of the pixels controls the seeds growth and it can be stopped with the help of the knowledge of the problem[19] [20].

The basic algorithm (based on 8- connectivity) steps for region growing method are:

If p(x,y) is the original image that is to be segmented and s(x,y) is the binary image where the seeds are located. Let 'T' be any predicate which is to be tested for each (x,y) location.

- First of all, all the connected components of "s" are eroded.
- Compute a binary image P_T. Where P_T (x, y) = 1, if T(x, y) = True.
- Compute a binary image 'q', where q(x, y) = 1, if P_T(x, y) = 1 and (x, y) is 8-connected to seed in 's'.[1]

2. Edge or Boundary Based Segmentation

2.1 Edge Detection Methods[21] [22]**:**

2.1.1 Roberts Detection

This Robert cross operator is used to compute 2D spatial gradient measurements on the image. It performs the operations simple and quickly. It highlights the regions of high spatial frequency that corresponds to the edges. At each point, the pixel value represents the absolute magnitude of the spatial gradient of the input image.

+1	0	0	+1
0	-1	-1	0

G_x G_y

fig. 9. roberts mask

2.2.2 Prewitt Detection:

The Prewitt edge detector estimates the orientation and magnitude of the edge. As differential gradient edge detection is time consuming, thus Prewitt detection is simple and appropriate. In this, most of the orientation estimates are not much more accurate. Prewitt detector is gradient based edge detector that used to estimate 3x3 neighbourhood for eight directions. For this, all the eight convolution masks are calculated.

-1	+1	+1
-1	-2	+1
-1	+1	+1

0^0

+1	+1	+1
-1	-2	+1
-1	-1	+1

45^0

fig. 10. prewitt mask

2.2.3 Sobel Detection

This operator also performs the 2D spatial gradient measurements on an image and emphasizes the regions of high spatial frequency that corresponds to edges. It is similar to Robert cross operator. At each point of gray scale image, absolute gradient magnitude is estimated. It consists of 3x3 convolution kernels. One kernel is simple and other is rotated by 90^0 as shown in fig.9 [23] .

-1	0	+1
-2	0	+2
-1	0	+1

G_x

+1	+2	+1
0	0	0
-1	-2	-1

G_y

fig. 11. sobel mask

2.2 Edge Detection Soft Computing Approaches [23]

2.1.1. Fuzzy Logic Approach [24][25]

In this approach, pixels of an image are divided into fuzzy sets such that each pixel of image belongs to many sets and regions of image. Specific edge detections can be developed in pre-defined neighbourhoods by using fuzzy rules as shown in fig.10.

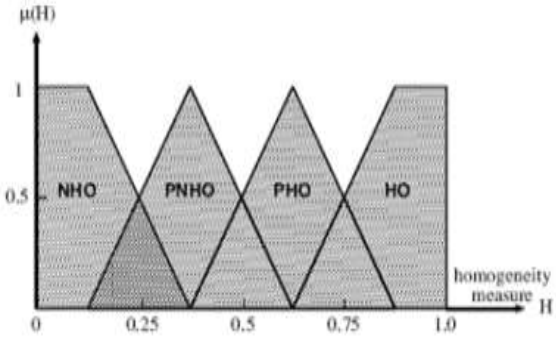

fig. 12. fuzzy sets used for homogeneity inference

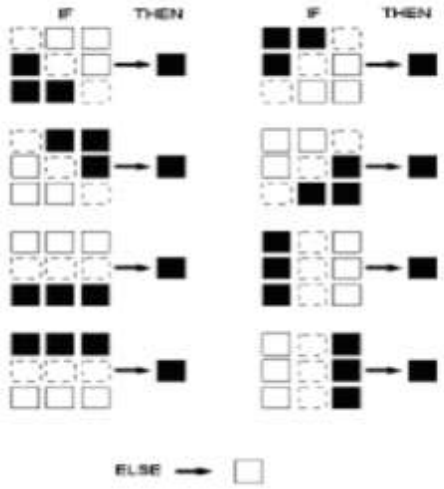

fig.13. neighbourhood of central pixel

2.1.2. Genetic Algorithm Approach

The genetic algorithm is derived from evolution theory. This approach is used for boundary detection. Genetic algorithm consists of major three operations: selection, crossover and mutation. Genetic Algorithm is capable to deal with complex or large search area where minimum knowledge is available about the objective. It is better than classical edge detectors [26].

2.1.3. Neural Network Approach

Several elements which are connected by links with variable weight, are the Neural Networks. Artificial neural networks (ANN) are used in various applications such as pattern recognition. This method is also used in noisy images also and detects highest edge pixels.

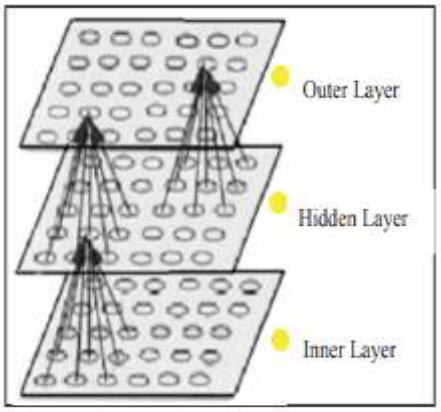

Fig.14. Neural network

V. COMPARISON BETWEEN REGION AND EDGE BASED SEGMENTATION

table1. comparison of segmentation techniques

	Region Based Segmentation	Edge Based Segmentation
Description	Divides the image into parts and or group the partitions into regions based on their similarities.	Based on discontinuity in the intensity values of an image and detect the edges by changing the intensity values of an image.

Methods	Thresholding, Split and Merge, Clustering, Region Growing	Roberts, Prewitt, Sobel, Soft Computing Approaches
Advantages	Gives better and accurate results. Provides clear object boundaries. Simple to implement and computationally fast.	Gives better result for contrast images. Features of images such as line, curve and corners can be extracted from edges.
Disadvantages	Computational cost is large. Time and memory consuming.	Not suitable for noisy and edgeless images. Not suitable for the images having very smooth boundaries. Size of operator and computational complexity proportional to each other.

VI. CONCLUSION

In this paper, detail and comparative study of region based segmentation and edge based segmentation techniques is evaluated. From the study, this can be concluded that Image segmentation is used to extract the object in image and the techniques of segmentation depend on various features of image such as color, intensity values, texture, contents, pixels, similarities etc. It is a challenging image process in future and used in many real life applications.

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