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IMAGE SEGMENTATION TECHNIQUES: A REVIEW

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Abstract— As a result of segmentation, an image is divided into several distinct portions, each of which has equivalent characteristics for each pixel. As an illustration, segmentation ought to be completed once the application's objects of interest have been isolated. The extent to which this partition is carried out is decided by the problem that is being solved. Image segmentation is a technique that is required by computer vision applications in order to extract the significant regions of an image. It would appear that image segmentation is a technology that shows great potential for usage in medical applications. When it comes to the realm of medicine, it is utilized to differentiate between things of interest and the background. Through the process of image segmentation, the representation of a picture can be clarified and/or transformed into a format that is more meaningful and easier to comprehend.

For the purposes of pattern recognition and image processing, picture segmentation is an indispensable element. An image segmentation system that is based on neural networks is being developed particularly for the purpose of segmenting color images. We will begin by presenting the BP Neural Network, which is capable of doing parallel computing, distributed saving, self-study, fault-tolerance, and nonlinear function approximation. Consequently, it is frequently utilized in the process of image segmentation; nonetheless, it is not devoid of any shortcomings. As a consequence of this, a novel approach to the segmentation of images is given. This approach is based on Wavelet Decomposition as well as a self-organizing graph neural network. When it comes to repelling noise, improving convergence, and other similar tasks, it is superior. This is an excellent method for estimating the color of an object, and color prototypes are exactly that. For the purpose of classifying picture pixels, color prototype matching is utilized. The findings of the studies indicate that the system had the capability that was considered to be desirable for the segmentation of color images in a variety of vision tasks.

INDEX - Image segmentation, Clustering, Wavelet Decomposition, ANN.

I. INTRODUCTION

The term "Image Engineering" is used to describe the degree of image segmentation that occurs during image processing. In the process of image engineering, there are three stages. image processing is a form of low-level processing that operates at the pixel level. (a) Image processing is a type of processor. The intermediate level is image analysis, which focuses on measurement. (a) Image analysis is the intermediate level. (c) Image understanding is a high-level operation that requires a more in-depth examination into the nature of each target and their interactions, in addition to providing an explanation

of the image that was first captured. Image segmentation is an essential stage that occurs between the stages of image processing and picture analysis.

Image segmentation techniques or procedures can be broken down into two basic categories: layer-based segmentation approaches and block-based segmentation techniques.

You can see the situation depicted in picture 1. Layer-based approaches are utilized for the purpose of object recognition and picture segmentation. These approaches combine the output of a bank of object detectors in order to generate form masks and explain appearance, depth ordering, and identify two class and instance segmentation [1]. The approaches that are based on blocks are supported by a multitude of elements that are present in the image. These elements include color information for the purpose of generating histograms, pixel information for the purpose of signaling edge, boundary, or texture information. [2] Block-based approaches can be broken down into two categories: those that are based on regions and those that are based on edges or boundaries. In the field of region-based approaches, some of the techniques that are utilized include clustering, split and merge, normalized cuts, region growth, and threshold measurements. Within the context of edge or boundary-based processes, the Roberts, Prewitt, and Sobel approaches are utilized. Some of the approaches that fall under the category of soft computing include fuzzy logic, genetic algorithms, and neural networks.

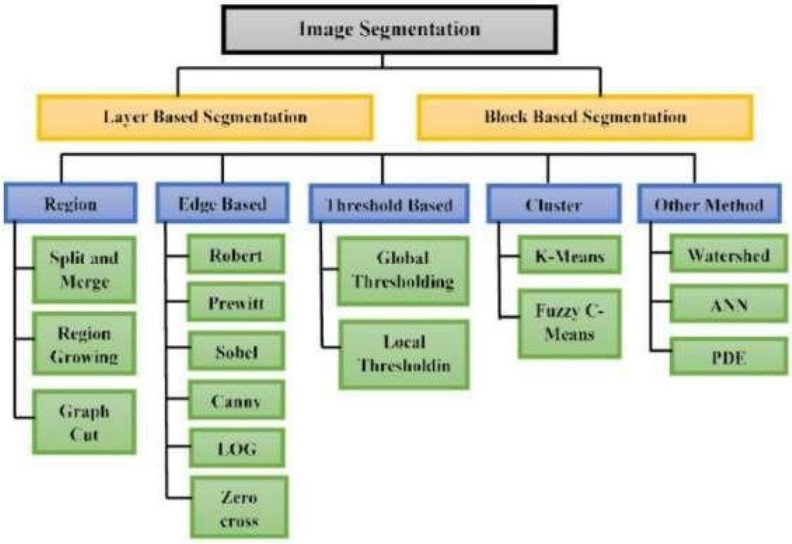

Fig 1: Image Segmentation Methods

The findings of the experiment conducted by Thakre N and colleagues [3] led them to the conclusion that it provides more satisfactory outcomes for the detection of shadows in terms of accuracy and Mathew's correlation coefficient. According to Amandeep Kaur et al[4] the normalized cut methodology presents discrimination in a manner that is significantly more transparent than the graph cut method provides. As a result of the findings, the graph cut method is unable to differentiate between components of identical intensity, even when they are separated spatially from one another. A seed selection algorithm was proposed by Uppu Lokesh and colleagues [5] for the purpose of seeded region growing. The purpose of this work is to demonstrate how that methodology can be utilized to accomplish automatic image segmentation, as well as how that method can be utilized to implement object identification systems. In situations where images are tainted with artifacts and noise, Rahul Basak et al. [6] are able to bypass the widespread flaws that are associated with thresholding techniques. By employing a fuzzy membership function, it is able to link every pixel in the image to separate output centroids, hence removing the need for any decision-making that is initially difficult. After conducting research, N. Senthilkumaran and colleagues [6] came to the realization that sift computing is advantageous. The methods are evaluated using a real-world example photograph of a natural setting, and the results demonstrate that image segmentation is an effective method. The strategy for thresholding the histogram that was suggested by D Veerendra and colleagues [7] was based on the comparability of grey levels. For the purpose of

analyzing such commonalities, a fuzzy measure is utilized. As stated by Naveen et al.[8], genetic algorithms are the most powerful and unbiased optimization tools that may be used to sample a large solution. According to Marco Manfredi et al. [9], the method that has been developed is a hybrid method that combines the advantages of two different clustering techniques. These techniques are neural networks and k-means. Furthermore, a wide variety of color-texture descriptor combinations were investigated in order to identify the most suitable descriptor out of all the options. DE, a powerful optimization tool, was utilized in order to determine the optimal mix of sensors that might be utilized for accurate skin detection.

II. RELATED WORK

The process of breaking down a picture into its component parts in order to extract data from the attributes of the image is referred to as image segmentation. In light of this, effective segmentation ought to produce regions in which the elements of the picture are consistent with regard to their brightness, color, texture, and other characteristics. A number of distinct types of segmentation processes can be distinguished from one another. Each strategy comes with its own individual set of advantages and disadvantages.

Swapan Samaddar and Dr. A RamaSwamy Reddy [10] state that there is no one methodology that can be used to segment all types of images, and that a single image can be segmented using a variety of different methods. In their survey, he explored the various applications that make use of the concept of picture segmentation. These applications include computer vision, medical imaging, scanning, and recognition, among others. In their study, Naveen Sai and colleagues [11] described an automatic threshold selection approach for the purpose of object segmentation from a colourful image. The method has the potential to be utilized in the process of identifying and defining human walking patterns. In his assessment of the image segmentation study, K Sankar [12] brought attention to a number of different approaches and issues that are associated with digital image processing and are utilized in a variety of unique identification patterns. As stated by Akshath M J and colleagues [13], image segmentation algorithms have the potential to be utilized in a wide range of advanced missions for the purpose of identifying specific regions of images or elements of things. According to Umar, Syed [14], the objective of image segmentation is to divide a picture into discrete portions that have calculated qualities that do not change, such as the brightness, color, or texture of the image. Easy segmentation can be achieved by the utilization of adaptive thresholding. Based on the findings of Gupta R. Gnanakumaran et al[15], the methods that should be utilized for the purpose of generating printed or handwritten text document images are significantly different. Furthermore, the results demonstrate that the pixel counting algorithm is most effective when used to printed text texts. The algorithm is simple to implement. If the handwritten document has some kind of guidelines or if the text size and interline spacing are consistent, then this method can be utilized with the handwritten document; nevertheless, when working with handwritten text images, it does not give appropriate results. It is also necessary to incur additional expenses, such as purchasing a skew correction module. For the purpose of generating the first centroid, Priyansh Sharma and colleagues [16] proposed the segmentation of a picture by employing the k-mean clustering technique in conjunction with subtractive clustering. For the purpose of enhancing the quality of the original image, the technique of partially contrast stretching is utilized, whilst the median filter is utilized to enhance the segmented image. After that, the final segmented result is compared to the k-means clustering technique, and the conclusion that is reached is that the clustering approach that was presented delivers superior segmentation. It is also possible to alter the output images by adjusting the radius of the hyper sphere cluster. With this information, we can draw the conclusion that we can get a wide range of output by adjusting the radius of the hype sphere cluster.

III. K-MEANS CLUSTERING

Unsupervised learning is a technique that is widely used in a broad variety of applications, including data mining [16]. The k-Means algorithm is a well-known unsupervised learning technique that is used because of its simplicity. Iterative K-Means In clustering, the 'n' observations are separated into 'k' groups, and each observation is assigned to the cluster that has the mean that is closest to it. There is a centroid for every cluster, and it is important that these centroids be described and distinct from those of other clusters.

The next stage, which comes after the definition of the k centroids, is to assign each point in a data collection to the centroid that is closest to it. The completion of the groupage occurs when there are no outstanding points. The barycenters of the clusters that were formed during the phase before this one are then recalculated with the addition of k additional centroids. After that, a loop is used to bind the same data set points as well as the new centroid that is closest to them. During the course of the loop, the k centroids will gradually change their positions, and the loop will come to a conclusion when there is no more room for modification. The simplicity of K means clustering makes it an effective method for working with massive databases. In the case when k is relatively low, k-means has the potential to be more computationally efficient than alternative methods such as hierarchical clustering [17]. There is a possibility that K-means clustering will produce clusters that are more compact than hierarchical clustering. In the field of medical image segmentation, the detection of brain tumors and the retrieval of content-based images are just a few examples of the applications to consider.

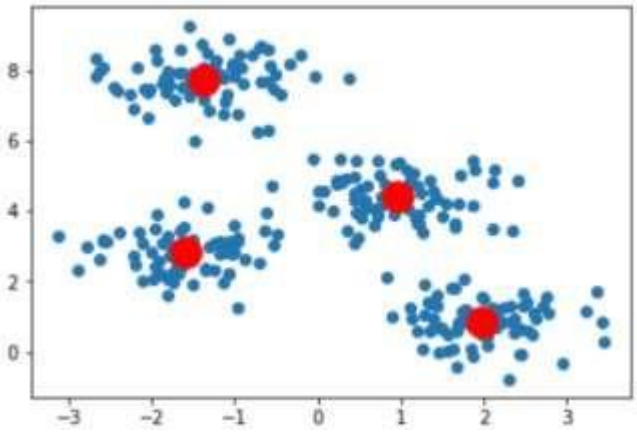

Fig 2: Clustering

Consider the following scenario: there is a picture with a resolution of 'x*y'. Image must be divided into a total of 'k' clusters. Assume 'p(x, y)' is a clustering input pixel, and 'ck' is cluster centres. The k-means [17] clustering technique iteratively:
For every pixel of image, compute Euclidean distance *d*, amongst center and every pixel of image using the formula given as:
1. Set the number of clusters k and the centre.
2. Through using formula below, estimate the Euclidean distance d between the centre and each pixel of an image for each pixel.

$$d = ||p(x, y) - ck|| \quad (1)$$

3. Based on the distance d, allocate all pixels to nearest centre.
4. Once all pixels were assigned, recalculate new position of centre using formula below.

$$ck = 1/k \sum_{y \in ck} \sum_{x \in ck} p(x,y) \quad (2)$$

5. The process is continued until the tolerance or error value is satisfied.
6. Resize and reshape the cluster pixels to fit the image.

K-means clustering is a straightforward method to implement, although it does have a few limitations. The most significant problem with this approach is that the quality of the final clustering results is contingent on the selection of the starting centroid, which is completely arbitrary. As a consequence of this, the outcome will be different for various initial centers regardless of whether the first centroid is selected at random or not. As a consequence of this, the beginning center will be chosen with great

effort in order to accomplish the segmentation that we are looking for. K-means clustering has a number of shortcomings, one of which is its computational complexity, which must be taken into consideration from the beginning. It varies according to the number of data items, clusters, and iterations that are used [16].

Jaskirat kaur et. al. [19] presented a split and merge technique for image segmentation. This split and merge strategy was introduced. The purpose of this research is to identify defects that are present in fruit skin. Using the k-means clustering approach, the original image has been over-segmented in the L*a*b* colour space. In the next step, smaller regions are merged with surrounding regions in order to sort them out. In order to facilitate the process of merging, RAG is constructed by utilizing sections that were collected from the stage before it. Integration of regions is accomplished by an iterative process using the minimal spanning tree technique. The findings demonstrated that this method is superior to the k-means only method in terms of quality and speed, as it utilizes regions generated by split operation as initial universe rather than pixels. Additionally, the results demonstrated that this strategy is faster than graph-based algorithms. Vinita M [20] describes the K-means clustering approach as an iterative process for classifying data points into K groups depending on the degree to which they are similar to one another. The well-known clustering problem can be simplified using this unsupervised learning strategy, which is one of the most straightforward methods available. K-means clustering is incorporated into the new clustering segmentation strategy that was proposed by Pratibha et al. [18]. This approach also takes into account information about regions and borders. In order to achieve color image segmentation.

IV. BPANN

The process of extracting particular characteristics from an image that contains a complicated background and a great deal of noise is the foundation of image recognition technology. The traditional approach makes use of an R, G, and B threshold in order to determine whether or not a point pertains to the target pixel. Prior to using the BP network to picture segmentation, we should first train the BP network so that it may be applied to the same difficulties. Image segmentation can be accomplished by the utilization of homogeneous zones when BP Neural Networks are utilized [21]. Color clustering is a common method, which is then followed by the elimination of pixels that are not the target group. Throughout the process of training the BP network, the weight vector wij that is distributed among the layers of neurons is modified. A representation of the topology of BP Neural Networks is shown in Figure 1. In the input mode, the nodes of the input layer are routed directly to the nodes of the hidden layer.

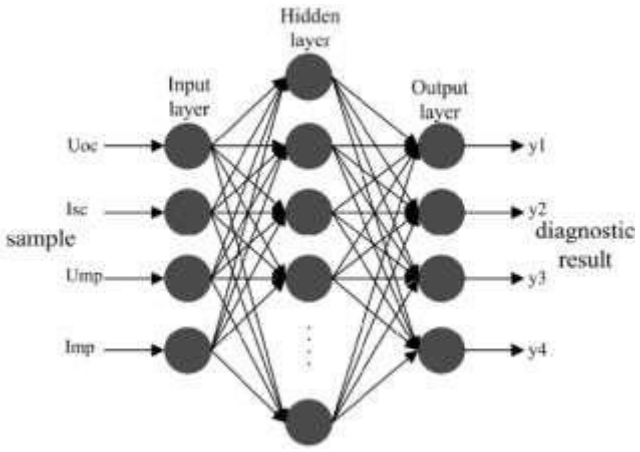

Fig 2: The BP Neural Networks system's structure

The pixel classifier in the BP Neural Networks is trained for the best division of colour space using a sample of object colours. By allocating each pixel to one of the predetermined classes, the image is segmented. Take, for illustration, one hidden layer node j, whose input is as:

$$y(j) = \sum_{i=1}^{M} w_{ij}\, O_i \qquad (3)$$

The output is presented as:

$$O_j = f(y_j) = \frac{1}{1+\exp(\frac{netj-\theta j}{\theta 0})} \qquad (4)$$

θj is a threshold.

Consider that there are training samples P, where P is the number of training samples (1,2,3,4, ... P). If output values Ok diverge from the target dk, we shall send back and constantly adjust the process, as well as the weight vector wij, during the process dissemination. The following is the error function:

$$E_p = 0.5 \sum_{k=1}^{M} (d_{pk} - o_{pk})^2 \qquad (5)$$

$$E = \sum_{p=1}^{p} E_p \qquad (6)$$
$$p$$

Because of inherent defects such as "blind spots" in neurons, complicated networks structure, slowly constringency pace, and so on, some mistakes are inescapable. An improved neural network strategy that focuses on Wavelet Decomposition as well as the Self-organizing Map Neural Network (SOM) is shown in the following.

V. CLASSIFICATION OF IMAGE SEGMENTATION TECHNIQUES

For the purpose of image segmentation, there are a number of different techniques that are now in use. Every single one of these methods is significant in its own right. All of these techniques can be approached from two fundamental approaches to segmentation, which are known as edge-based approaches and region-based approaches respectively. In order to accomplish the necessary segmentation, each technique can be utilized on a variety of separate photos. There are three categories that can be used to classify all of these different strategies [3, 4].

A. Structural Segmentation Techniques

The structural techniques are those techniques of image segmentation that relies upon the information of the structure of required portion of the image i.e. the required region which is to be segmented.

B. Stochastic Segmentation Techniques

The stochastic techniques are those techniques of the image segmentation that works on the discrete pixel values of the
image instead of the structural information of region.

C. Hybrid Techniques

The hybrid techniques are those techniques of the image segmentation that uses the concepts of both above techniques i.e.
these uses discrete pixel and structural information together [5].

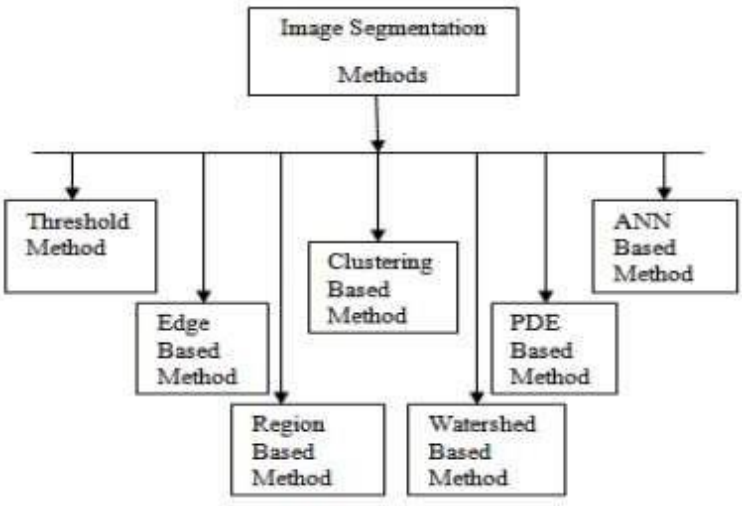

Fig. 3 Image segmentation techniques

In further parts of this paper the various techniques of segmentation are discussed and compared. Mathematical description is avoided for simplicity therefore all the techniques are described theoretically. The popular techniques used for image segmentation are: thresholding method, edge detection based techniques, region based techniques, clustering based techniques,

Watershed based techniques, partial differential equation based and artificial neural network based techniques etc [21]. These all

techniques are different from each other with respect to the method used by these for segmentation.

VI. CONCLUSION

Different picture segmentation approaches are studied in this research. Layer focused segmentation and block based segmentation are the two fundamental methods that are utilized in the process of making a picture segmentation. Block-based image segmentation can be further classified into two categories: region-based segmentation and edge or boundary-based segmentation. Each of these categories can be further subdivided into subcategories. It is not possible to find a segmentation method that is universally applicable to all types of photographs; rather, the image can be segmented using a number of different approaches.

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REFERENCES

[1] Sukhjeet Kaur, Navneet Kaur, "A Survey of Brain Tumour Segmentation Methods: A Review", International Journal on Future Revolution in Computer Science & Communication Engineering ISSN: 2454-4248 Volume: 4 Issue: 5, pp. 92-96, May 2018.

[2] Uppu Lokesh , Naveen Sai Bommina , Nandipati Sai Akash , Dr. Hussain Syed , Dr. Syed Umar. (2021). Deep Reinforcement Learning with Genetic Algorithm Tuning for Intrusion Detection in IoT Systems. International Journal of Communication Networks and Information Security (IJCNIS), 13(3), 582–595.

[3] Thakre N, Nimma D, Turukmane AV, Singh AK, Rohatgi D, Bangaru B (2024) Dynamic path planning for autonomous robots in forest fire scenarios using hybrid deep reinforcement learning and particle swarm optimization. Int J Adv Comput Sci Appl 15(9).

[4] Amandeep Kaur, Rakesh Kumar, Kamaljeet Kainth, "Review Paper on Image Segmentation Techniques", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 6, Issue 7, pp. 336-339, July 2016.

[5] Uppu Lokesh, Naveen Sai Bommina, Nandipati Sai Akash, Dr. Hussain Syed, Dr. Syed Umar, "Designing Energy-Efficient and Secure IoT Architectures Using Evolutionary Optimization Algorithms", International Journal of Applied Engineering & Technology, Vol. 4 No.2, September, 2022.

[6] Rahul Basak, Surya Chakraborty, Aditya Kumar Mondal, Satarupa Bagchi Biswas, "Image Segmentation Techniques: A Survey", International Research Journal of Engineering and Technology (IRJET), Volume: 05, Issue: 04, pp. 51-57, Apr-2018.

[7] D Veerendra, BN Umesh, A Khandare, D Rohatgi, K Tiwari, S Datta, "ECA-MURE algorithm and CRB analysis for high-precision DOA estimation in coprime sensor arrays", IEEE Sensors Letters 7 (12), 1-4.

[8] Naveen Sai Bommina , Nandipati Sai Akash, Uppu Lokesh , Dr. Hussain Syed , Dr. Syed Umar, "Multi-Objective Genetic Algorithms for Secure Routing and Data Privacy in IoT Networks", International Journal of Communication Networks and Information Security (IJCNIS), (2020), 12(3), 632–643.

[9] Marco Manfredi, Costantino Grana and Rita Cucchiara, "Learning Graph Cut Energy Functions for Image Segmentation"

[10] Swapan Samaddar, Dr. A RamaSwamy Reddy, "COMPARATIVE STUDY OF IMAGE SEGMENTATION TECHNIQUES ON CHRONIC KIDNEY DISEASES", International Journal of Pure and Applied Mathematics, Special Issue, Volume 118, 2018, pp 235-239

[11] Naveen Sai Bommina , Nandipati Sai Akash, Uppu Lokesh , Dr. Hussain Syed , Dr. Syed Umar, "Privacy-Preserving Federated Learning for IoT Devices with Secure Model Optimization", International Journal of Communication Networks and Information Security (IJCNIS), (2021), 13(2), 396–405.

[12] K Sankar, Divya Rohatgi, S Balakrishna Reddy, "COX Regressive Winsorized Correlated Convolutional Deep Belief Boltzmann Network for Covid-19 Prediction with Big Data", Grenze International Journal of Engineering & Technology (GIJET), Grenze ID: 01.GIJET.9.1.547, © Grenze Scientific Society, 2023.

[13] Akshath M J, H. S. Sheshadri, "Hybrid Edge Detection Techniques for MR Image Analysis", International Research Journal of Advanced Engineering and Science, Volume 2, Issue 1, pp. 79-83, 2017.

[14] Umar, Syed, Bommina Naveen Sai, Nagineni Sai Lasya,Doppalapudi Asutosh, and LohithaRani. "Machine Learning based Sentiment Analysis of Product Reviews Using DeepEmbedding." Journal of Optoelectronics Laser 41, no. 6(2022): 108-113.

[15] R. Gnanakumaran, Divya Rohatgi, A K Sampath, Nidhi Nagar, D. Amuthaguka, Raj Kumar Gupta, "Robust Extreme Learning Machine based Sentiment Analysis and Classification", 2023 5th International Conference on Smart Systems and Inventive Technology (ICSSIT), (2023), DOI: 10.1109/ICSSIT55814.2023.10061017.

[16] Priyansh Sharma and Jenkin Suji, "A Review on Image Segmentation with its Clustering Techniques", International Journal of Signal Processing, Image Processing and Pattern Recognition Vol.9, No.5, pp.209-218, 2016.

[17] Lahouaoui Lalaoui, Tayeb. Mohamadi, and Abdelhak Djaalab, "New Method for Image Segmentation", Science Direct, 2015.

[18] Er. Pratibha Thakur, Er. Nishi Madaan, "A Survey Of Image Segmentation Techniques", International Journal Of Research In Computer Applications And Robotics, April 2014.

[19] Jaskirat kaur, Sunil Agrawal and Dr. Renu Vig, "PERFORMANCE ANALYSIS OF CLUSTERING BASED IMAGE SEGMENTATION AND OPTIMIZATION METHODS", Computer Science & Information Technology (CS & IT), pp. 245–254, 2012.

[20] Vinita M. Tajane, Prof. N.J.Janwe, "Identifying Healthy and Infected Medicinal Plants Using Canny Edge Detection Algorithm and CBIR" National Conference On Research Trends In Electronics, Computer Science & Information Technology And Doctoral Research Meet, Feb 21st & 22nd.

[21] Deepa karungan, Dr .N. Sujatha "SURVEY ON VARIOUS IMAGE SEGMENTATION TECHNIQUES", Journal of Emerging Technologies and Innovative Research (JETIR), February 2017.