# A REVIEW OF RECENT IMAGE SEGMENTATION TECHNIQUES

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*Abstract:* Various research studies have been conducted in the field of Image Segmentation over the last few decades. While some of the studies have tried to overcome the shortcomings of the previous methods of segmentation, some of them have focused new and unique applications of image segmentation, through their own innovation. This paper reviews some of the most prominent research contributions on this topic of image segmentation. A summary of the objectives and applications of each method is explained in a way to give sufficient information about the crux of the matter. The reviews are arranged in a chronological order, so as to highlight the evolution of the study material and addition of various innovative techniques. The robustness and effectiveness of each method, based on the conducted experiments and obtained results are mentioned. Also, the demerits of the methods, cost factors, future scope and other parameters are discussed wherever required.

*Index Terms* – **Edge-based Segmentation, Graph Theory, Image Processing, Image Segmentation, Preprocessing.**

## I. INTRODUCTION

Image segmentation is one of the trending and widely used operations of computer vision and image engineering. The basic meaning of Image segmentation is to divide a digital image into smaller parts, also known as group areas, identifying the various distinct objects and analyzing and separating the various objects. The objects are distinguished considering various parameters such as intensity, location and color of the pixels, background, foreground, edges, brightness levels, etc. The low-level information such as grey level, color and texture are vital in image segmentation, processing and analysis. Mainly two characteristics of pixels are considered for segmentation, i.e. similarity and distinctness. The main objective is to obtain an image from the target image that is easier to decode and analyze.

There are various methods that are used for image segmentation. However, there hasn't been any method till date that is effective for all applications of image segmentation. Speaking of which, there are a heap of applications of image segmentation, which are used in the 21st century for critical operations. In the medical field, X-ray scans, MRI (Magnetic resonance imaging) scans and CT (Computed tomography) scans are used on a large scale where image segmentation helps in diagnosis of different tumors, fractures, or other ailments found in the internal organs of the human body. Also, image segmentation is a vital aspect of phase contrast microscopy, which provides information on multi-cell processes. Another application is geographical image segmentation, which is used for global mapping of various geographical areas, while also monitoring vast landscape changes of different regions. It is also used in addressing some critical national and military operations, i.e for satellite surveillance and analysis. Nowadays, in this digital age, many other applications have also emerged such as fingerprint and retinal scans. Segmentation is used to validate the data obtained by these scans. Likewise, there are many other applications were image segmentation serves as the backbone.

## II. LITERATURE REVIEW

[1] In the year 2006, a Content-Based Image Segmentation for Large-scale Spatial Images was proposed. This method intended to overcome the challenge of organizing and analyzing vast volumes of image data to effectively synthesize the critical information from the large scale spatial image. The motivation behind this, as well as its application, was to acquire image data for developing spatial and geographical data, as well as critical military and national data. This approach used content descriptors based on visual data, as they are data driven and void of the fluctuations based on semantic interpretation. Color histogram method was used on a spatial image, for segmentation to oak ridge, green tree areas and water areas which would help in the desired applications. This was an overall nice method, mainly focused for segmentation of geographical images, and there was a lot of scope for improvement using techniques such as Gabor filter, Wavelet transform, autocorrelation, Segmentation of Edges, Measure of regular random objects, Shapes of objects, and others.

[2] In 2009, there was a paper published on Segmentation of Fingerprint Images Using Minimal Graph Cuts. As the name suggests, it was purely focused on image segmentation of fingerprint scans. In this paper, an efficient technique was proposed for fingerprint image segmentation using minimal graph cuts for making the labeling smoother and more coherent, minimizing the boundary factors. The objective of fingerprint segmentation is to extract the region of interest (ROI) which contains the desired fingerprint impression. A graph cut process, heuristic segmentation method based on gray mean and variance and mini-cut segmentation method based on gray mean and variance were used on the fingerprint image. The basic aim of fingerprint segmentation is to separate the foreground area from the background area. This method yielded much accurate and satisfying results even in cases of noise contained in the images.

[3] In 2010, a Medical Image Segmentation Based on Watershed and Graph Theory was introduced. A segmentation approach that combines watershed algorithm with graph theory is proposed in this theory, in order to address the issues such as strong noise, poor gray-scale contrast, blurred margins of tissue, in medical images. The main working procedure behind this theory involved calculating gradient image, reconstructing gradient image, calculating floating point active image and then performing watershed segmentation followed by graph cut for fine segmentation. Compared with traditional watershed algorithm, this algorithm doesn't only improve over-segmentation phenomenon of watershed algorithm and the problem of large data during segmentation which use Grab Cut algorithm directly, but also retain detailed information as much as possible. This innovation was very satisfactory in case of medical field, where proper image segmentation is a must.

[4] In 2010, a paper was published, discussing A New Image Segmentation Method Based on Grey Graph Cut. To improve the performance of image segmentation, the paper suggested a new image segmentation method based on grey graph cut, which integrates grey theory and graph cut theory. This method achieved not only image segmentation with obvious difference between targets and backgrounds, but also suppressed image noise effectively. A noise-free visible light image, a noised image, and a real SAR image were experimented for testing the robustness of the method. Experimental results showed that the method is efficient when original images are polluted by noise or targets have obvious difference from background. This method was very well defined and multipurposeful, and overall it was very satisfactory.

[5] In the year 2010, A New Approach for Image Segmentation with MATLAB was proposed. This method utilized the MATLAB framework of programming environment which integrates thresholding, edge extraction and color information. Along with the implementation, the merits and demerits of the proposed were also properly mentioned in the published paper. It worked using combination of edge detection function, hue, saturation and intensity functions, combine function and finally the segmentation function. This method claimed to perform better than the built-in MATLAB edge detection function. The experiments conducted produced good results in both true color and binary format, and even reduced some of the noise contained in the image. However, output was not much satisfactory for images with highly prominent backgrounds.

[6] In 2010, another paper was presented which was named MATLAB Implementation of Image Segmentation Algorithms. This paper presented the implementation of image segmentation using the GUI feature of the MATLAB and one best result could be selected for any algorithm using the subjective evaluation. The research gave one algorithm for each image segmentation technique, and even displayed the duration of segmentation during each algorithm. Different images were segmented using various techniques such as Canny algorithm, Split and Merge Method, Thresholding Algorithm, Fuzzy C Means Clustering Method, Graph cut, Mean Shift Method, Normalized cut method, etc. The study concluded that different algorithms were satisfactory for different segmentations. There is need for more research to come with a single technique which can be effective in multiple scenarios.

[7] In 2011, a Study on Solder Joint Image Segmentation Techniques Based on Matlab was undertaken. The method of image segmentation proposed in the said study revolved around the concept of color image processing, as opposed to the earlier grey scale image processing, with the use of MATLAB. It showed that the color image processing, which contained hue and saturation factors, obtained better objects at segmentation. Soldier joint processing technique was used on an SMT image using the MATLAB toolbox. This study was a great and simple idea highlighting that color image segmentation methods were better than the grey scale image segmentation methods that that loses color information during segmentation processing.

[8] In 2012, a study research paper was introduced which was titled as Image Segmentation Method Based on Improved Graph Cut Algorithm. The idea was to improve the speed of graph cut and solve the watershed transformation over-segmentation phenomena in image segmentation. First, the watershed transformation was applied, then the corresponding pixels were replaced with partition information of the watershed transformation and finally the graph cut algorithm is employed to realize network graph segmentation and get the segmentation results. The algorithm was overall efficient and much useful to the medical image processing, used to split the brain's gray matter and white matter.

[9] In 2012, a Multilevel Graph Cuts based Image Segmentation was proposed. This method used the multilevel graph partitioning approach along with normalized cuts framework for segmentation of gray scale, color and texture images. Proper care was taken to ensure the evaluation of different methodologies considering the fact that image perception was inconsistent, i.e the ground truth was analyzed. A very detailed and defined algorithm was put forward explaining the implementation of Graph cut method for the segmentation process. It mainly involved three steps; using multilevel graph cuts to coarsen the graph to a certain level, partitioning the graph using normalized graph cuts framework and finally uncoarsening it to normal graph obtain final segmented image. This method showed good results by optimizing the graph development process, and also reduced effective computational time.

[10] In the year of 2015, a study paper was proposed titled Cell Segmentation And Tracking In Phase Contrast Images Using Graph Cut With Asymmetric Boundary Costs. This paper focused on segmentation of cells in phase contrast microscopy images. The key feature used for segmentation was said to be the heavy dark to bright transitions at the boundaries. The method was compared to the traditional graph cut approach, and showed relatively efficient and accurate segmentation. It showed a large improvement regarding quality and robustness in phase contrast images. The method was very promising and claimed to outperform even the standard min-cut segmentation with symmetric boundary costs. In overall, this method was a very great innovation for cell segmentation images.

[11] In the year 2018, a study paper was proposed titled Grab Cut Image segmentation Based on Image Region. This paper focused on Grab Cut Algorithm. According to this paper this algorithm uses texture information and boundary information of image and achieves good segmentation results with a smaller number of user interaction. But there are few drawbacks of this algorithm. Firstly if the background is complex or the background and the objective is very similar the segmentation will not be very good. On the other hand, the relatively slow speed and Complex iterative process of the algorithm are greatly limited to its application. In order to overcome this problem this paper proposed an improved grab cut algorithm which is the combination of grab cut and graph based image segmentation. Nevertheless, the improved algorithm increases time cost ,it improves the performance in the complex background. Thus in this paper, this improved algorithm has been applied to more complex situation and it also had given the accurate results.

[12] In 2018, Brain Tumor Segmentation in MRI images using Chan- Vese Technique in MATLAB was introduced. This paper focuses on the segmentation of tumors from the medical images which in turn plays an important role in the diagnosis and treatment of malignant tumors .This paper presents an improved image segmentation technique named Chan-Vese which is based on total variation methods for accurately segmenting the tumors from brain MRI image set. This paper incorporates Chan -Vese model with the number of iteration for performing the region of interest based segmentation for obtaining the desired results at respective iteration more flexibly. This technique is more flexible than the previously reported methods in a way that it gives user the freedom to determine and set the number of iterations allowing them to get the desired results at respective iteration. This proposed technique yields promising segmentation results. Moreover this technique can be further extended and used in various other medical imaging modalities for obtaining precise clinical information rapidly.

[13] In the year 2019, an approach to Analysis and Experimental Research of Modification of the Image Segmentation Method Using Graph theory was made. This paper investigates the problem of image segmentation based on the color difference of the region. The objective of this paper is to increase the processing speed of the image segmentation and to improve the segmentation quality on textured images. In order to achieve this objective different ways of representing segments were considered . Modification algorithm with the use of superpixelization has been introduced in this paper which helps to avoid the resegmentation on the textured areas of the images. This paper investigates the dependence of the segmentation quality on the choice of the metric of difference in the pixels colors. This paper uses CIE2000 metric by which the best quality segmentation has been achieved. In order to balance segmentation quality and speed CIE76 metric is used. This paper examines the dependence of the segmentation outcome with the use of superpixels. These superpixels improves the quality of segmentation and also reduces the re-segmentation on textured areas of image

[14] In 2020, there was a paper published on A Review of Image Segmentation using MATLAB. The objective of this paper is to give a detail information and a great importance of Image Segmentation techniques in understanding and analyzing objects within images. This papers gives a detail information about the different types of digital images and image segmentation techniques. Algorithms discuss in this paper are capable of transforming opaque images into meaningful ones through which vital information can be extracted in the medical field. However, methods and techniques discuss in this paper are not able to detect all the objects in the images we used. These techniques can easily evaluate high density images whereas some of the images with low density pixels or low color uniformity could not be analyzed properly. So in order to achieve this deep learning techniques shall be introduced.

[15] In 2020, Segmentation of White Blood Cells using Image Segmentation Algorithm was introduced. This segmentation approach of images plays a key role in Image Processing as it separates a broader image into many smaller parts. As the name suggests its objective is to identify the Nucleus of the White Blood cells which in turn will allow the haematologists to clearly identify the WBCs .In this paper different segmentation techniques has been proposed out of which Edge detection and K- mean based segmentation is considered to be the most suitable approach for segmenting WBC cells.

## III. OUR FINDINGS FROM STUDIED LITERATURE

The findings from critically analyzed around sixty reviews and research papers are summarized below:
- Fixed threshold and local measures cannot be employed for good segmentation as it has many drawbacks.
- Simply breaking the MST edges or edges with high weights would result in improper segmentation.
- The Eigen-vector based segmentation approaches are two slow for practical applications and the segments obtained by these approaches are computationally important but perceptually important regions are not obtained.
- The normalized cut criterion provides a significant advance over the previous works. However, the normalized cut criterion also yields an NP-hard computational problem. In practice these approximations are still fairly hard to compute, limiting the approach to relatively small images or requiring computation times of several minutes.
- Graph cuts algorithm based on iterated region merging requires lot of user interaction.
- In the image segmentation based on mean shift and normalized cuts, the spatial structure and the detailed edge information of an image are not preserved.
- If the image is treated as an undirected weighted non-planar finite graph and image segmentation is handled as graph partitioning problem, then the approach could not segment the images having high over-lapping of objects or very dark images.
- If weighted Euclidean distance is used to calculate the edge weight, then the efficiency becomes less.

- When the segmentation is done based on the principle that in a Eulerian circuit, each edge is
- traversed only once and further segregation in open and closed sub-graphs is done by choosing critical vertices at a minimum directed distance, the algorithm itself cannot trace the boundary in images. The input of traced boundary is, thus, to be given; so more user interaction is required.
- When the objects to be segmented contain similar colors with the background, Grab Cut might fail to correctly segment them.
- The iterated region merging-based graph cuts algorithm requires a lot of user interaction. However, the approach can capture regions that are important as per human perception

## IV. FUTURE WORK

In future, we will implement the image segmentation using tools from graph theory after preprocessing the image using coherence filter and wavelet transform. Suggested approach exploits the graph theory. Amongst the various segmentation approaches, the graph theoretic approaches in image segmentation make the formulation of the problem more flexible and the computation more resourceful. The problem can be modeled in terms of partitioning a graph into several sub-graphs; such that each of them represents a meaningful region in the image. The segmentation problem is then can be solved in a spatially discrete space by the graph theory.

## V. DISCUSSION

Existing literature is summarized based on the content of the relevant research papers, Finally, the findings are identified for the same research papers. Gist of the studied research papers is presented in brief. In particular, this paper provided the direction to solve the image segmentation problem through the graph theory based suggested approach. Presented work is very useful to the beginners in the domain of image processing, particularly who want to work in the image segmentation.

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**BIOGRAPHIES**

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