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Implementation of Image Segmentation with Graph Cut Method

Samruddhi Bawane[1], Prof. Hemant Turkar[2], Prof. Ravi Asati[3]
[1, 2, 3]Computer Science & Engineering, RTMNU University, India

***Abstract:** In image processing, segmentation is the process of partitioning digital image into multiple sets of pixels, according to some homogeneity standard. The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyze. Segmentation by computing a minimal cut in a graph is a new and quite general approach for segmenting images. This approach guarantees global solutions, which always find best solution. Graph cut has emerged as a preferred method to solve a class of energy minimization problems such as Image Segmentation. In this paper we used graph cut method to solve image segmentation problem and we got successful results in image segmentation. In this project we proposed a new approach by using optimized normalized cut with combination with K-means algorithm to do the segmentation of static image. In this method we used efficient computational technique based on eigen values and eigen vectors to get optimized segmented image.*
***Keywords:** Image processing, Image segmentation, Graph cut, Normalized cut, K-Means*

I. INTRODUCTION

Image processing is a very vast concept. To perform some operations on an image, in order to get an improved image or to extract some useful information from it the concept of image processing is used. It is a type of signal processing in which input is an image and output may be image or characteristics or features associated with that image. Currently image processing is among rapidly rising technologies as it also forms core research area in engineering and computer science specialties. In computer vision, Image segmentation is an important image processing technique. Image segmentation is the process of dividing a digital image into multiple segments. To simplify the image or change the representation of an image into something that is more communicative and easier to analyze is the main aim of image segmentation. Image segmentation is typically used to trace objects and boundaries in images. Particularly segmentation of image is the process of giving a tag to every pixel in an image such that pixels with the same tag share some uniqueness.

There are many image segmentation techniques that are established to segment the image in a better way. Image segmentation algorithms are developed based on two basic properties of intensity values:

A. Discontinuity based

In discontinuity based approach the partition is done based on some abrupt changes in gray level intensity of the image.

1) Detection of Isolated Points
2) Detection of Lines
3) Edge Detection

B. Similarity based

In similarity based approach segmentation is done based on grouping of pixels based on some features.

1) Thresholding
2) Region growing
3) Region Splitting and Merging
4) Clustering
5) K–Means Clustering
6) Fuzzy C Means Clustering

A lot of interest grab by Graph cut based segmentation method because this method utilizes both information of image i.e. boundary and regional information. Furthermore, graph cut based method is efficient and accepted worldwide since it can achieve globally optimal result for the energy function. It is not only promising to specific image with known information but also effective to the

natural image without any pre-known information. For the segmentation of N-dimensional image, graph cut based methods are also applicable. Due to the advantages of graph cut, various methods have been proposed.
The rest of the paper is arranged as follows. Section 2 explains the related work. Section 3 outlines the proposed work, Section 4 gives the outcome and Section 5 concludes the paper.

II. LITERATURE REVIEW

Yuri Boykov, Vladimir Kolmogorov proposed an experimental comparison of the efficiency of min-cut/max flow algorithms for applications in vision and compares the running times of several standard algorithms, as well as a new algorithm that they have developed. The algorithms they study include both Goldberg-Tarjan style "push-relabel" methods and algorithms based on Ford-Fulkerson style "augmenting paths." They benchmark these algorithms on a number of typical graphs in the contexts of image restoration, stereo, and segmentation. Their new algorithm method, making near real-time presentation possible in many cases [1].
Alexander Fix, Aritanan Gruber, Endre Boros, Ramin Zabih propose an alternative construction to Ishikawa's, with improved theoretical and experimental performance. Instead of considering terms in the energy function one at a time, they consider many terms at once and review existing methods for solving higher-order MRF's with graph cuts [2].
Hirnori Shigeta, Tomohiro Mashita, Takeshie Kaneko, Junichee Kikuta, Haruo Takemura, Hideo Matsuda and Masaru Ishii proposed a method for the analysis of a sequence of bone tissue images taken by a two-photon microscope to quantify blood permeability of bone marrow. This method segments the input image sequence to blood vessel, bone marrow and bone regions by graph cuts which extended according to the images. Permeability is quantified by the intensity of the segmentation result [3].
Shuangfeng Dai, Ke Lu, Jiyang Dong propose a new lung segmentation method based on an improved graph cuts algorithm from the energy function. The lung CT image is modelled with Gaussian mixture models (GMMs), and the optimized distribution parameters can be obtained with expectation maximization (EM) algorithm. The lung image edges information is used to improve the boundary penalty item of graph cuts energy function [4].
Jianbo Shi and Jitendra Malik proposed normalized cut method which is an unbiased measure of disassociation between subgroups of a graph and it has the nice property that minimizing normalized cut leads straight to maximizing the normalized association, which is an unbiased measure for total association within the subsections. In finding an effective algorithm for computing the minimum normalized cut [25].

III.PROPOSED WORK

Firstly the aim of this project is to study graph cut method for segmenting images and study in what way they perform in practice. Secondly to propose new graph cut algorithm which gives better image segmentation results in compare with other two existing algorithm. In this project we use RGB color model to get better segmented image. We implement the existing boykov algorithm and voronoi algorithm

A. Boykov Algorithm

In our work firstly we need to find the minimum cut and maximum flow of the flow graphs for the segmentation of image. Boykov is the technique used in the graph cut technique for finding the minimum cut and maximum flow:
Steps for the Boykov algorithm:
This algorithm has following three stages:
1. growth stage: search trees S and T grow until they touch giving an *s t* path,
2. augmentation stage: the found path is augmented, search tree(s) break into forest(s),
3. adoption stage: trees S and T are restored.

B. Voronoi Algorithm

Voronoi based Preflow Push is the algorithm for finding the maximum flow.
The main steps of this algorithm are as follows:
1) Initialization
2) Create Voronoi region graphs around sink clusters.
3) In each Voronoi region, first push flow from source cluster to sink cluster boundary and then push flow within sink cluster.
4) Rebuild Voronoi region graphs around remaining sink clusters.
a) *Initialization:* For all source and sink nodes *excess*(*v*) is set equal to source capacity if v is a source or equal to negative of sink capacity if v is a sink. With every node v of the grid graph we associate label d(v) called distance label.

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b) *Create Voronoi region graphs nearby sink clusters:* Collection of nodes in which there is a path between any two nodes passing through only nodes in the collection is called a clusters. Voronoi region contains one sink cluster and one or more source clusters which are reachable from given sink cluster. Push flow" operation is performed per Voronoi Region.

c) *Push Flow:* Push flow happens in two phases. From a node, flow is pushed saturating the out edges till the node has no excess left or all out edges of the node get saturated. The saturated edges are deleted and a node whose all out-edges are deleted is inserted in a list called Disconnected List*(DL).* Second phase moves the excess (which is accumulated at boundary nodes of a sink cluster), inside the sink cluster. Second phase starts from those sink cluster boundary nodes with positive excess on them and then pushes the excess inside the cluster in a breadth first way.

d) *Rebuild Voronoi:* In Rebuild operation, first we identify all such nodes whose distance labels need to be corrected. An augmenting path from a node v in *DL*(*d*) to a sink in the new residual graph will necessarily have to pass through a node which has its path to sink intact i.e. it has retained its shortest distance label after a push flow stage.

The image segmentation by this two above existing algorithm gives the output as given in fig.

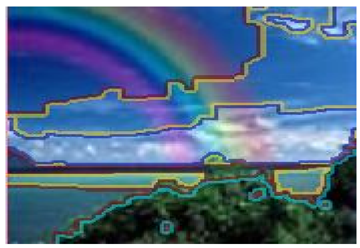
 Figure: Input Image	 Figure: Segmented image output by Boykov algorithm	 Figure: Segmented image output by voronoi Algorithm

Fig 1: Existing Graph cut Algorithms Segmented Image output

C. Proposed approach

Here in the proposed work we have used the optimized normalized cut with k-mean clustering technique for getting the better result. To avoid the unnatural bias for partitioning out small sets of points, proposes a new measure of disassociation between two groups i.e Normalized cut algorithm.

1) *Formula for finding normalized cut*

A graph G= (V, E) can be partitioned into two disjoint sets, A, B, A U B = V, A ∩B =Φ

$$\mathrm{cut}(A,B) = \sum_{u\in A, v\in B} w(u,v)$$

The ***normalized cut*** then could be defined as:

$$N_{cut}(A,B) = \frac{\mathrm{cut}(A,B)}{\mathrm{asso}(A,V)} + \frac{\mathrm{cut}(A,B)}{\mathrm{asso}(B,V)}$$

Where, cut(A,B) is sum of all the edge weights associated with cut

asso(A,V) is sum of all the edge weights associated with the cut and all the points in the graph

Ncut algorithm:

Let,

$D(i)=\sum_j W_{ij}$

Also, let *D* be an n*n diagonal matrix with d on the diagonal, and let W be an n*n symmetric matrix with Wij=Wji.

After some algebraic manipulations, we get,

Min ncut(S,S')= $\min_y \frac{Y^t(D-W)y}{Y^t D y}$ subject to the constraints:

a) Yi € {1,-b}, for some constant

b) Yt D1=0

Minimizing $\frac{Y^t(D-W)y}{Y^t Dy}$ subject to the constraints above is NP-hard. To make the problem tractable, we relax the constraints on Y, and allow it to take real values. The relaxed problem can be solved by solving the generalized eigenvalue problem (D-W)y =λDy for the second smallest generalized eigenvalue.

2) K-means: k-means have the idea of an optimal segmentation. Assume that each pixel in the image is distributed according to some number of independent probability density functions i.e. Gaussians. The ideal segmentation is one where each pixel has the highest probability of belonging to the segment it is in, compared to any other possible segment we could make. To segment an image using k-means we do the following: First initialize the image to k arbitrary segments and compute the mean of all the pixels in the segment, factoring in both spatial and intensity values. Then, for each pixel p, find the segment for which the mean is closest in Euclidean distance to p, and reassign p to that segment. After all the pixels have been reassigned, restart the algorithm by recomputing the means and finding new assignments for each pixel. Continue until no pixels move segments.

3) The partitioning algorithm:

a) Given a set of features, set up a weighted graph G = (V,E), compute the weight of each edge, and summarize the information in D and W.
b) Solve (D-W) y =λ Dy for eigenvectors with the second smallest eigenvalues.
c) Use the eigenvector with the second smallest eigenvalue to bipartition the graph (e.g. grouping according to sign).
d) Decide if the current partition should be subdivided.
e) Recursively partition the segmented parts, if necessary.

Input image | Output of proposed approach

Fig 2: Segmented image after proposed approach

IV. RESULT

In this paper we have discuss the graph cut method algorithms and proposed a new approach for image segmentation. For fair and meaningful comparison of methods, the segmentation quality is measured using the Dice Coefficient metric and Time parameter. The *Dice* Coefficient is *used* as an *objective* criterion to measure the quality of segmentation. The following table shows the comparison between existing and proposed approach for image segmentation.

Algorithm	Time	Dice
Boykov algorithm	10.0628	1.5702
Voronoi algoritm	68.4957	1.0192
Proposed approach	6.9642	0.9977

Table 1: Comparison table

Table shows that the dice value of our proposed approach is lower which shows that our proposed approach gives the better segmented result.

V. CONCLUSION

There are many approaches for solving Image Segmentation problem, currently Graph cut based methods are preferred most over other approaches. We have used the existing algorithm Voronoi based Push Preflow for finding the minimum cut and maximum flow in the graph cut and we get the output as the segmentation of image. This algorithm efficiently worked for finding the minimum cut of the flow graph and it easily segment the image but doesn't give the proper quality segmented image. Our proposed approach focuses on extracting the global impression of an image rather than focusing on local features and their consistencies in the image data. Proposed approach uses normalized cut and k-means algorithm which gives the optimized result.

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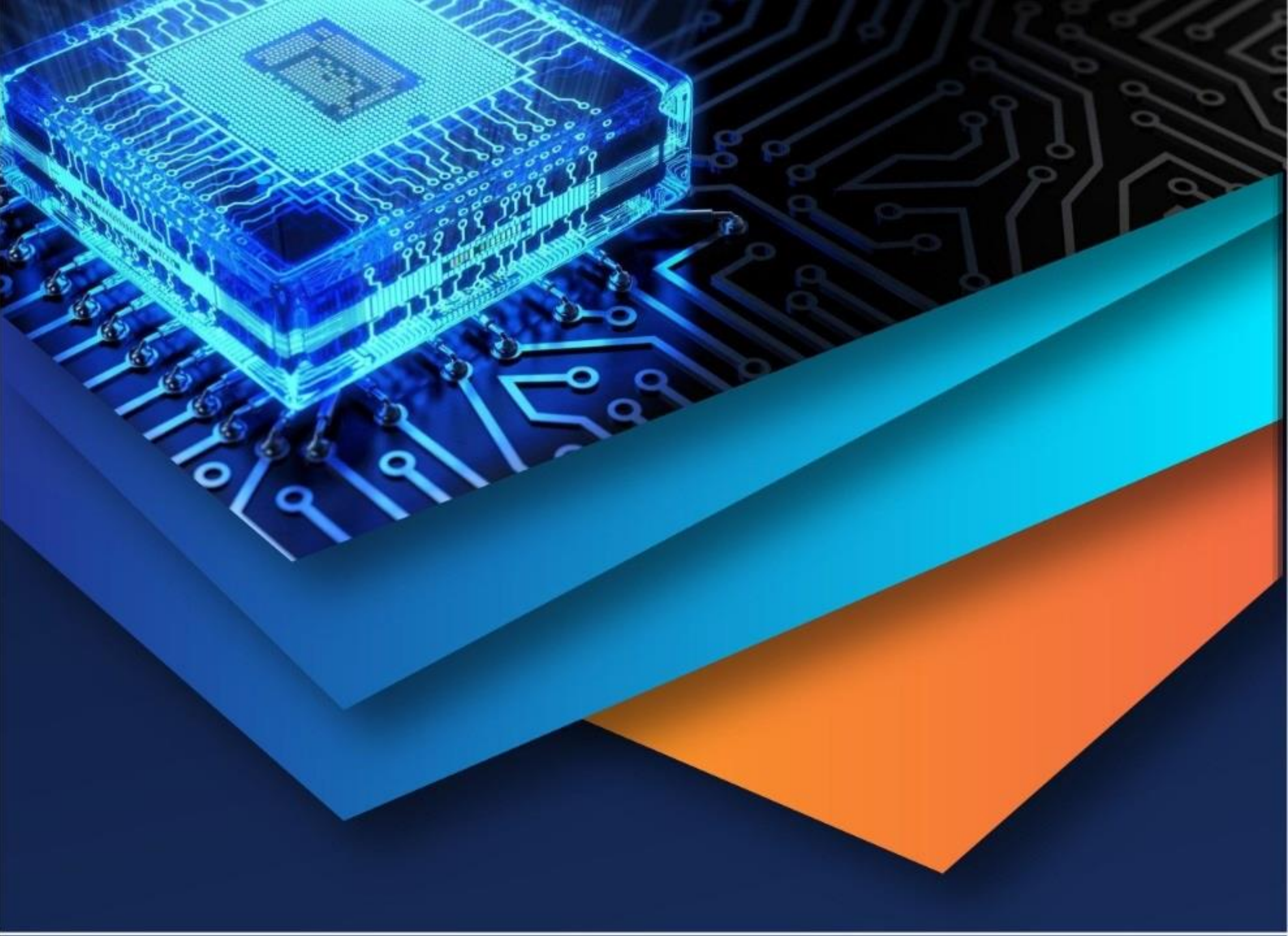

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