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Edge Information based Seed Placement Guidance to Single Seeded Region Growing Algorithm

Rajendra V. Patil[1], Dr. Renu Aggarwal[2]

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Abstract: The split of the picture into regions that represent various objects or parts of an object has been referred to as image segmentation. An image is split with the objective of studying each object and getting some higher-level information. A wide range of segmentation approaches are either region-based or edge-based. By using likeness criteria among candidate sets of pixels, the region-based division split an image into distinct regions of related pixels. The choice of the starting seed points is the primary challenge for region growing algorithm in order to achieve attractive image subdivision. The region growing process is an extremely effective and trusted approach for segmenting images. In this paper, an autonomous method based on edge information is proposed to predict initial region development seed for single seeded region growing algorithm. Illumination invariant Log Gabor wavelet based phase congruency method is employed for edge detection. Edge line processing technique is utilized to determine region-growing seed for single seeded region growing algorithm.

Keywords: *Region Growing, Phase Congruency, Log Gabor Wavelet, Edge detection, Image Segmentation*

1. Introduction

The segmenting images is the operation of splitting an image into segments whose characteristics are identical with regard to some particular attributes, and which, ideally, match the actual items in the scene [1.2]. By pixels into groups and producing regions of similarities, segmentation plays a vital part in obtaining useful information from an image in order to create homogenous areas. The basic prerequisite for any imaging-based application is picture segmentation due to the fact that in the majority of cases, individuals are only interested in certain areas of the image [1, 2, 4]. Objects that are non-overlapping and possess pixels identical in characteristics are the outcomes of image segmentation. Security mechanisms, healthcare diagnosis, identifying objects, vision in computers, robotics vision, healthcare imaging, aerial image analysis, earth observations etc. are some of the usage areas for automatic segmentation of imagery [1, 2, 3, 4, 5]. To execute segmenting an image, there are six fundamental approaches [6] to choose from: thresholding algorithms [7], edge-based techniques [9], region-based techniques [11], clustering based solutions [10], fusion based approaches [11], and soft-computing techniques [37].

In [2, 4, and 12], an in-depth review of various strategies is given. Image segmentation is still a topic of research despite the various segmentation approaches that have been put out in the numerous works. Due to the variety of applications, it is not possible to declare that the issue of segmenting images has been completely solved [12].

The diversity of the intensity, surface, and shape in general-use images of nature makes autonomous segmentation a difficult issue [2]. In the context of the segmentation of complicated imagery like outside and natural scenes, that contain extra challenges because of effects like lighting, points of interest, non-regular sunlight, or structure, it is frequently tough to achieve satisfactory outcomes by employing only a single of these methods. It may be achievable to minimize issues with each individual method by utilizing the complimentary nature of edge-based and region-based approaches. The best course of action appears to be the tendency with merging multiple techniques [12].

In this paper a novel method for determining region development seed to improve the results of single seeded region growing algorithm is proposed. This approach requires no human participation and is totally autonomous. Edges are obtained using log Gabor wavelet based phase congruency feature detector [14, 15, 20, 21]. Long edges reflect regional identity in images [14, 15]. Short length edges are caused due to texture or noise in image. Long boundaries are of greater value for recognizing objects in image. Color similarity of longer boundaries is determined. Color similar boundaries assigned same label. Centroid of longer edges having same label is calculated. Centroid of longer edge is regarded as initial region development seed for region growing algorithm.

The remaining sections of the article are structured as follows: Section 2 reviews methods integrating region and boundary information. The suggested boundary-based automatic region development seed placement approach is described in Section 3. The log-Gabor (LoG) wavelet based edge method is introduced in Section 4, and Section 6 presents results from experimentation to demonstrate the viability of our suggestion. Finally, Section 7 provides conclusions.

2. Related Work

The purpose of literature review is to identify different methods, their categorization, to find limitations and merits of various algorithms and to set a framework for proposed methodology in this work.

1 Research Scholar, Sunrise University, Alwar, Rajasthan, India
Assistant Professor, SSVPS Bapusaheb Shivajirao Deore College of Engineering, Dhule (M.S.), India
ORCID ID : 0009-0000-1105-0423
2 Research Supervisor, SunRise University, Alwar, Rajasthan, India
ORCID ID : 0009-0006-4852-2600
** Corresponding Author Email: patilrajendra.v@gmail.com*

The introductory parts of a number of studies contain an in-depth discussion upon a segmentation method that combines region and line [12, 23, 25, 26, 27, 28, 29]. Palvis et al [25], for example, present a few prior works that emphasize on the combination of various approaches for segmentation. Fatah [26] outlined two fundamental approaches in 1993 for integrating dual information, borders, and regions. The application of data from edges to regulate or improve the region's segmentation procedure is described as the first tactic. Another choice is to combine obtaining region and finding edges into a single procedure. When studying combination of various approaches, Le Moigne et al [30] distinguished between two types of integration: pixels and symbol. The assumption used in pixel inclusion in lines and regions refers to the choice to integrate is made based on a set of chosen attributes, which simplifies the issue. The authors additionally talk about post-processing and integrated methods while presenting benefit of after-treatment [30]. As it may use any kind of edge and region segmentation for initial activity, they contend that afterward fusion offers a more generalized method.

Embedded integration technique [30] that is most prevalent involves first retrieving border information, which is then utilized in the segmentation procedure, Fig. 1 depicts the method's fundamental structure. The detection of edges and processing provides additional data that can be utilized as decision-making criteria to region growing process. Boundary data, for instance, will be employed to determine the starting places from which regions are developed. The goal of this incorporation strategy is to leverage edge information as a way to improve outcomes of region-based methodologies.

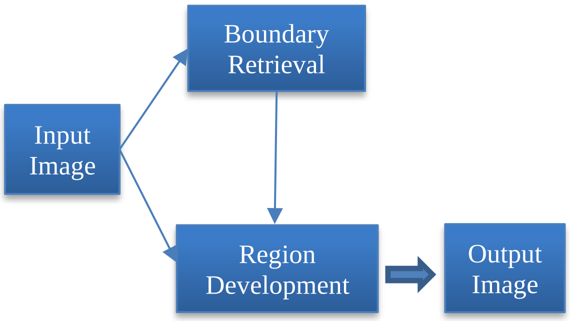


Fig. 1. Integration of Edge information and Region Growing

After the image has been processed using both edge-based and region based methods independently, edge data is used improve region-growing outcomes [29]. As a first stage, border and region results are retrieved separately, as seen in Fig. 2. The initial segmentation acquired by the one approach is then modified or refined using both types of information through an a posteriori fusion process. The purpose of this technique is to enhance the preliminary findings and generate a segmentation that is more precise.

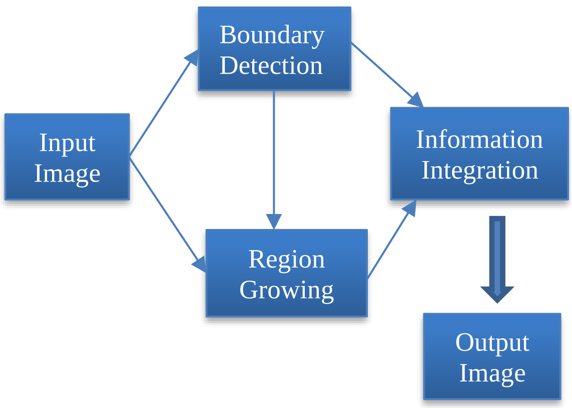


Fig. 2. Afterwards Processing

In the context of a region segmentation method, the embedded fusion approach usually makes use of previously extracted edge detail. This is common knowledge that the majority of region-based segmentation techniques rely on the initial region formation spots selected, while the specific development point selected will determine the form of the region. To get around these issues, some recommendations attempt to utilize edge knowledge [29]. There are two patterns that can be identified depending on how this knowledge is used [29]:

A. Control of Region Expansion

Edge data is incorporated in initial seed select criterion that regulates the expansion of region.

B. Seed for region development

The development spot (seed) for the region's growing procedure is chosen using information from the edges as a guide.

3. Edge Based Seed Placement Guidance

By conducting the literature survey it has been found that the most of the traditional segmentation techniques can provide good segmentation results if additional information is provided to these segmentation strategies. Success of Region growing algorithm depends on correct initial seed placements [29]. Many researchers have proposed different methods to approximate initial seed placement [29]. But there is no single strategy that provides good estimation of starting point for region growing algorithm.

This work uses a novel technique for color-based image segmentation employing embedded attributes [15]. For color image segmentation, a technique suggested by Xu Jei et al [14] is initially employed. In this work, the starting region development seed for the region-growing algorithm is determined using edge data.

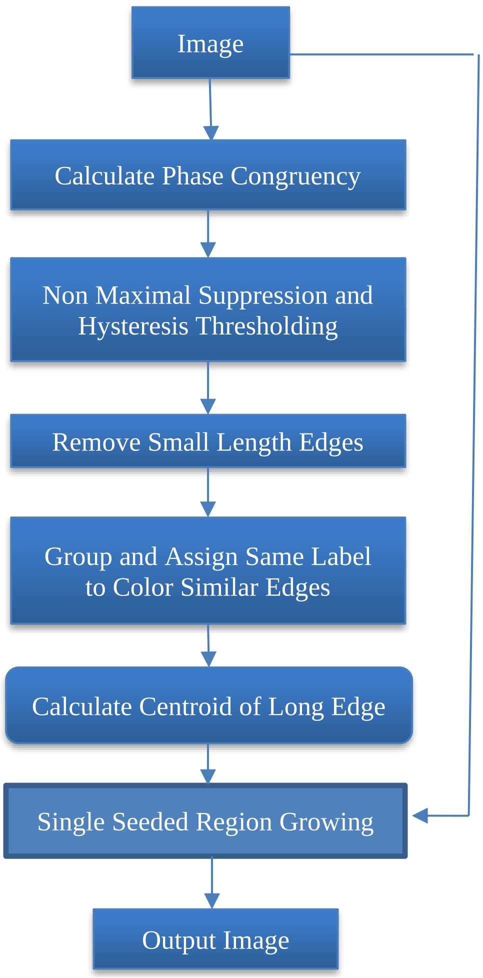


Fig. 3. Region Development Seed Placement Process

In this work, we utilized illumination invariant feature detector phase congruency for edge detection [18, 20, 21, 22]. To obtain edge segments, non-maximal suppression and hysteresis thresholing is employed. Shorter edge segments were removed because they represent the local nature of the image. The boundary for same homogenous region may be partitioned into several adjacent edges because obtained several adjacent color edges are discontinues, thus centroids may be very close and colors may be very similar. A line is formed by connecting the eight adjacent edge pixels. For each line segment, edge segment descriptor that consists of three color components hue, saturation and value, p percentage, the proportion of pixels on line i to all of the pixels in the image, as well as the algebraic averages of pixels called as centroids CN_x, CN_y is obtained. For each boundary E_i, edge Segment descriptor is constructed as follows [15]:

$$E_i = \{hue, sat, value, p, CN_x, CN_y\} \quad (1)$$

Where, three elements of color are hue, sat and value.

p = pixels on line E / Number of pixels in image I (2)

Centroids, which are calculated as the pixel's algebraic average,

$$CN_x = \frac{1}{n}\sum_{(x,y)\in i} x \,, CN_y = \frac{1}{n}\sum_{(x,y)\in i} y \quad (3)$$

Edge segment grouping is an approach used to group color similar edges [14, 15]. The mean color of every edge segment is calculated in order to put together edges with comparable colors. Euclid distance on mean color of each set of edge line's pair is determined. If the Euclidean distance on the mean color is less in edge segment pairs, the same label is given for the edge pairs.

This process is continued until distance on mean color between each line segment pair is below threshold. Edge descriptor is updated for each line segment. Centroid of long edge is calculated and considered as initial region development seed for region growing algorithm.

4. Edges Using Log Gabor Wavelet

Logarithmic Gabor wavelet (LoG) based novel feature detector, Phase Congruency (PhaseCong) is used to retrieve edges in image [18, 20, 21, 22, 31]. Edge and step results are obtained. Its qualities involve invariance to amplification and consistency to changes in illumination within images. According to the local energy model, features appear in an image precisely where each Fourier element is converging. Morrone and Owens were the designers of this model [22]. At the object's boundary and edge locations, phase congruency (PhaseCong) values are high. Peter Kovesi suggested using logarithmic Gabor wavelets to determine the phase congruency [20], [21], and [22]. LoG wavelets are employed because they can span wide-ranging frequencies while maintaining a zero bias voltage in the even oriented symmetrically filters. In Fourier space, filters are designed using polar positions. An angled part and the radial direction element make up the LoG's two components [20, 21]. Two parts multiply each other to get the whole filter. A collection of log Gabor wavelets (LoG's) are used in image convolution to calculate phase congruency at various scales and at different angular positions. Phase congruency at different scales and angles is computed via image convolution with an array of logarithmic Gabor wavelets (LoG's). Phase Congruency at particular locality is specified as [32]:

$$\begin{aligned} PhaseCong1^{or}(i,j) = \\ \sum_n WG^{or}\Big[AMP_n^{or}(i,j)\big(\cos(ph_n^{or}(i,j)) - ph_n^{-or}(i,j)\big) \\ - |\sin(ph_n^{or}(i,j) - ph_n^{-or}(i,j))| - NC\Big] \\ \times \left(\sum_n AMP_n^{or}(i,j) + \varepsilon\right)^{-1} \end{aligned} \quad (4)$$

Where the rotation angle value is or, The frequency spread-based weight element is $WG^{or}(i,j)$, and $AMP_n^{or}(i,j)$ and $ph_n^{-or}(i,j)$ are the amplitude and phase respectively, $Ph_n^{or}(i,j)$ is the weighted mean , NC is a noise constant, and ε is a small value. The symbols used indicate that the encased quantity is 0 when the value is negative and identical to itself if the value is positive. For details see [20, 21, and 32].

5. Region Growing

The region expanding method looks for neighbors of a seed point to see if they are also part of the same region. The fundamental goal of region growth is to map a set of pixels called a region from a collection of pixels called seeds in the input image. In 1994, Rolf Adams and Leanne Bischof [35] made the initial presentation of it. The region-growing technique starts with basic region development seeds and develops with nearby homogeneous components [33, 34, 35, and 36]. The process of region-growing method is summarized in following steps:

- As an initial seed, proceed with the centroid of the labeled long border. Pixels are added to one of the seed groups during every region-growing phase. The same sign (label) is used to identify all of the pixels in the identical area.
- Determine the locations of the nearby pixels. Make sure that the neighbor is either in or out of the picture.
- The region's mean color or intensity of pixel and differences in pixel color are determined.
- Add the pixel whose color or gray scale is most similar to the region's mean to the region. Determine the region's new mean.
- Delete the pixel from the collection of nearby (checked) pixels.

6. Experimental Results

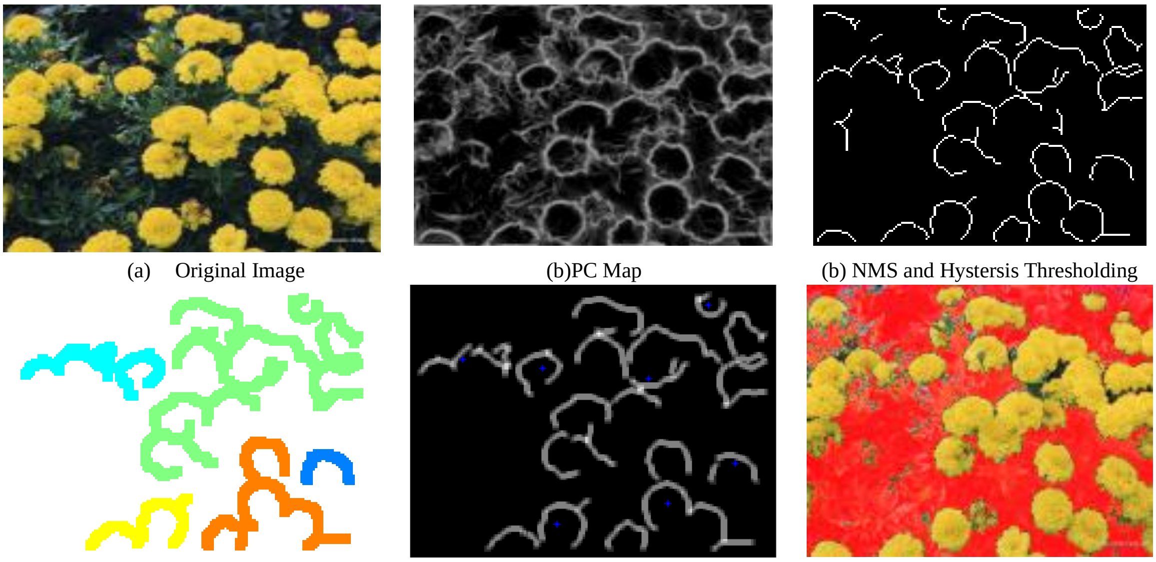
We have applied segmentation algorithm on a number of real natural images. A total of 30 images were selected which represent a wide variety of color images from the segmentation point of view. The segmentation outputs were displayed using a MATLAB based Graphical User Interface.

Edges were detected in terms of phase congruency. Given an image, we first generate its 2 D Phase congruency matrix. Peter Kovesi's "phasecong1" function is used for this purpose. Edge maps were obtained by performing non-maximal suppression on raw phase congruency image followed by hysteresis thresholding. For hysteresis thresholding, lower and upper threshold were set 0.2 and 0.4. Shorter edges that reflect regional features are omitted. Long edge outlines are first chosen as distinct clusters if their proportion is higher than a criterion. Color Similarity between each pair of edges is determined using distance measure such as Euclid. Color similar edges are clustered in a group and similar edges assigned same label. Grouping of edge objects is continued recursively till equality distance among the edge clusters is greater than threshold. Centroid of longer is determined and this centroid is considered as initial seed for region growing algorithm.

Components in the experiment's image are carefully labeled and used as the ground truth in order to quantitatively assess the segmentation outcomes. The segmentation results are then evaluated using the true positive rate (TPR) and false positive rate (FPR).

Table 1. TPR and FPR Values

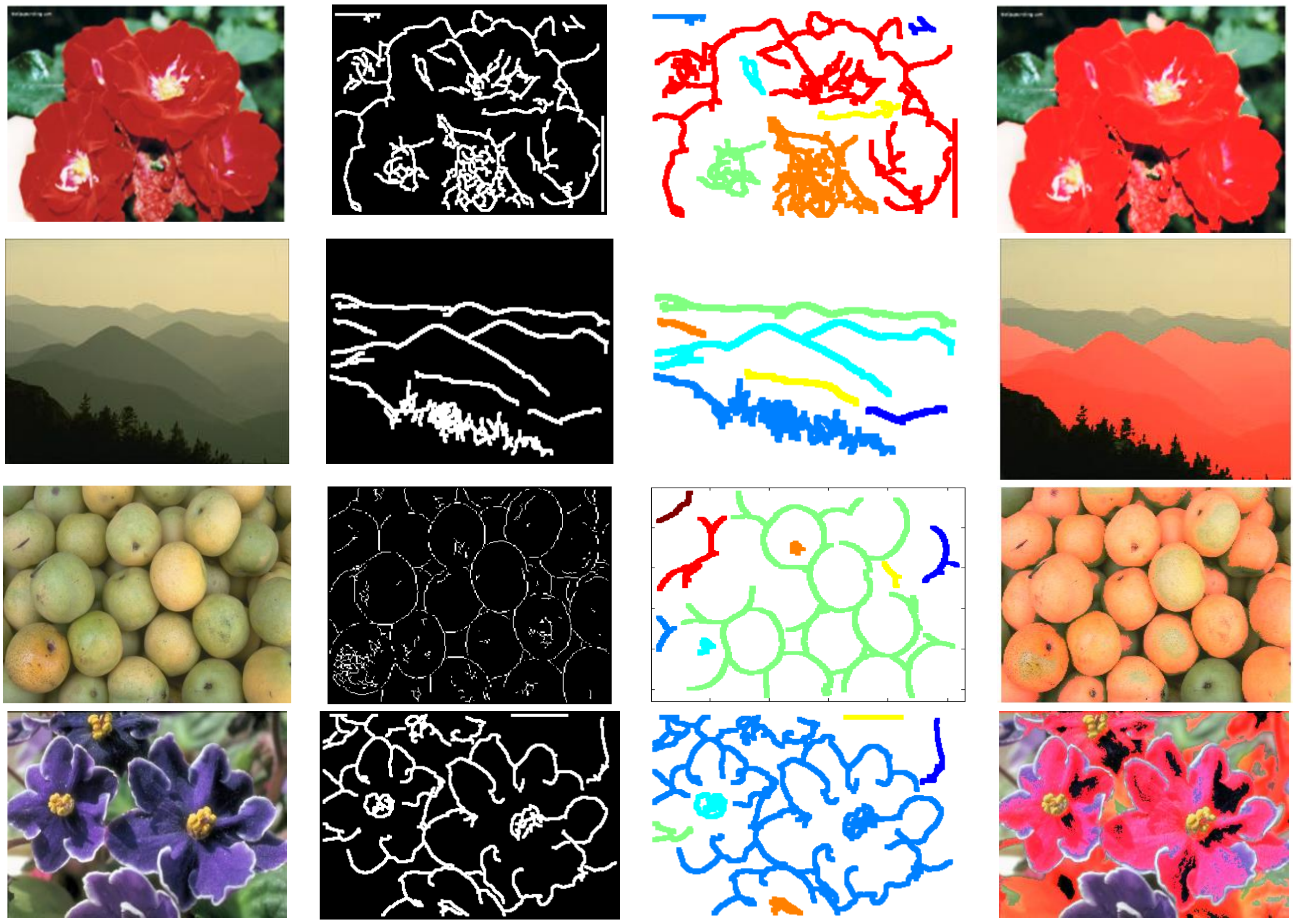
Image	Size	Number of Object Pixels	Number Of Backgrou nd Pixels	TPR (%)	FPR (%)
22.jpg	168*168	9305	18919	99%	3%
Flower1	285*217	40124	21721	95%	2%
Flowers2	163*122	7792	12094	98%	14%
Creek.jpg	307*230	13059	57551	61%	44%



(a) Original Image (b)PC Map (b) NMS and Hystersis Thresholding

(d) Edge Line Grouping (e) Centroids (f) Region Growing

Fig. 4. Region Development Steps : Image Flower



(a) (b) (c) (d)

Fig. 5. Segmentation Outputs (a) Original Image (b) Edges after short edge removal (b) Group color similar edges (d) Single seeded region growing segmentation output

The region growing algorithm we implemented is a single seed algorithm, which provides good segmentation results if there are fewer objects in the image. However, for naturally complex images, it leads to under segmentation

7. Conclusion

An automatic log Gabor wavelet based edge detection and edge preprocessing technique has been used for seed generation to single seeded region algorithm in this work. Both an edge-based seed generation algorithm and a single seeded region algorithm have been implemented using MATLAB. Starting region development seed for region growing is obtained automatically from centroid of longest boundary in image. Since longer edges are of greater importance to identify region, tiny edges depict the regional characteristics in images. Small length edges are regarded as unimportant features that are typically brought on by an object's structure. Evaluation of the segmentation results obtained using the proposed methodology is done using TPR and FPR. Performance evaluation shows that proposed method produces good results if there is less number of objects in image. But it results in under segmentation for natural real world images having complex structure

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Author contributions

Rajendra V. Patil: Conceptualization, Methodology, Software, Field study, Data curation, Writing-Original draft preparation, Software, Investigation, Writing-Reviewing and Editing

Dr. Renu Aggarwal: Validation, Investigation, Supervision

Conflicts of interest

The authors declare no conflicts of interest.

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