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Improvement of Single Seeded Region Growing Algorithm on Image Segmentation

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Keywords: image segmentation, seed pixel, region growing, homogeneity criteria.

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Improvement of Single Seeded Region Growing Algorithm on Image Segmentation

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I. Introduction

According to the information technology, an image is a visual representation of something on the Earth. A digital image is a set of pixels that is, comprises of a two dimensional array of individual picture elements called pixels represented in columns and rows. Each pixel expresses an area on surface of the Earth.

Image segmentation can be classified into two ways. First one is edge based segmentation and the second one is region based segmentation. Gray histogram and Gradient based method [1] are the main method of edge based segmentation. Common gradient based method are sobel operator, robert operator, prewitt operator, canny operator, Laplace operator, Laplacian of Gaussian (LOG) operator & so on, canny is the most promising one [2], but computation time is more as compared to sobel operator. The main methods of region based segmentation are region growing [3], region splitting and merging [4], watershed [2], [5]; cluster based segmentation and threshold based segmentation are also included in the region based segmentation method. Clustering [6], [7] based segmentation includes hard clustering or K-means clustering and Fuzzy clustering [8], where the threshold [9] based includes basic global thresholding, optimal thresholding using Otsu's method, multiple thresholding, variable thresholding, and multivariable thresholding.

For most of the image analysis and machine vision applications image segmentation is an essential process, and the seeded region growing (SRG) algorithm is one of the most fundamental methods used in image object segmentation. Region-based algorithms grouped neighboring pixels which have similar values and dividing groups of pixels which are heterogeneous in value. Regions may be grown from manually-positioned `seed' points, for example, selection of seed position by aggregation of pixel values. Research has shown that, seeded region growing was focused primarily on the selection of initial seeds, image object features, and the definition of region homogeneity. The objective of region growing is to map the input image into sets of connected pixels, called regions, according to a predefined criterion which generally examines the features of local groups of pixels. Basically, for image segmentation region growing algorithm is a general technique. The basic scheme consists of joining adjacent pixels to form regions followed by adjacent regions are then merged to obtain larger regions. The association of neighboring pixels or regions in the region growing process is governed by a homogeneity criterion that must be satisfied in order to combine pixels and regions. The homogeneity criterion is application dependent and may be dynamic within a given application. For solving the region growing problem, there are many algorithms in the literature. The performance of a particular algorithm depends on the application area i.e. domain and the image to be segmented [10]. Region based methods rely on the postulate that all neighboring pixels within the one region have similar value or a specific range [11].

Segmentation procedure becomes semi-automatic starting with an interactive seed point selection step, followed by the region growing process [12].

From many segmentation techniques, region growing is one of the easiest and efficient algorithms. In seeded region growing, the seed selection is a challenging process. By considering this limitation a method has been developed where a new seed selection technique is combined with the existing single seeded region growing method. In seed pixel selection process, after smoothing the input image by Gaussian

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filter the image has been divided into sub regions both row and column wise. Following the summation of the pixel intensity of the sub regions independently observe the sub region which have the highest summation values both row and column wise. After choosing a pixel position from the pragmatic region this algorithm has been combined with existing single seeded region growing.

For the experiment purpose an image dataset is taken from Berkeley Segmentation Dataset [13] containing a set of images with training and corresponding ground truth images for experiment and performance evaluations. The objective evaluation can be performed using three performance evaluation parameters. From the experimental results, it is concluded that the proposed method shows better efficiency than the other existing algorithms. In this experiment, the MATLAB 7.10.0 (R2010a) is used to process the images.

II. Seeded Region Growing Technique

a) *Seed Point Pixel*

Seeded region growing performs the segmentation of an image according to a set of pixels, known as seed pixel. These pixels should be brightest for better segmentation. An ideal candidate seed point should have these properties: i) It should be inside the region and near the centre of the region ii) Assume most of the pixels in the region of interest (ROI) belong to the region, the feature of this seed point should be close to the region average iii) The distances from the seed pixel to its neighbors should be small enough to allow continuous growing [11].

b) *Seeded Region Growing Process*

Seeded region growing (SRG) method for segmentation introduced by [14], is a simple and robust method of segmentation which is rapid and free of tuning parameters. Seeded region growing is a semi-automatic method of the merge type. User control over the high level knowledge of image components in the seed selection process makes it a better choice for easy implementation and applying it on a larger dataset.

There are two types of seeded region growing. One is *single seeded growing*, in which a single seed pixel is used to grow the region which is chosen manually. Another is *multiple seeded growing*, where a set of seed pixels are used to grow the region.

The growing process starts from a pixel which is known as the seed point initially selected by the user. The pixel can be chosen based on either its distance from the seed point, features of the image or the statistical properties of the neighborhood. Then each of the 4 or 8 neighbors of that pixel are visited to determine if they belong to the same region. This growing expands further by visiting the neighbors of each of these 4 or 8 neighbor pixels. This recursive process continues until either some termination criterion is met or all pixels in the image are examined. The result is a set of connected pixels determined to be located within the region of interest.

Seeded region growing approach to image segmentation is to segment an image into regions with respect to a set of q seeds as presented in [12] is discussed here. Given the set of seeds, S1, S2, …., Sq, each step of SRG involves identifying one additional pixel to one of the seed sets. Moreover, these initial seeds are further replaced by the centroids of these generated homogeneous regions, R1, R2, ……, Rq, by involving the additional pixels step by step. The pixels in the same region are labeled by the same symbol and the pixels in variant regions are labeled by different symbols. All these labeled pixels are called the allocated pixels, and the others are called the unallocated pixels [15].

c) *Homogeneity Criteria*

Success of region grow algorithm depends on the initial seed selection and criteria used to terminate the recursive region grow process. Hence choosing appropriate criteria is the key in extracting the desired regions. In general, these criteria include region homogeneity, object contrast with respect to background, strength of the region boundary, size, conformity to desired texture features like texture, shape, color [11]. In our work this criteria pay a dominant rule.

d) *Limitations*

Though region growing is effective for noisy image, the seeded region growing has a great drawback. This is the difficulty in initial seed selection. It is because, the selection of seed pixel during region grow process leads to different final segmentation results. That is why the process is time consuming if the effective pixel is not selected. In this article it has been analyzed and proposed an algorithm where the effective seed pixel can be selected.

III. Proposed Approach

In this research, an improved algorithm has been proposed for seeded region growing in image segmentation. The proposed improved algorithm is worked with single seed pixel. The seed pixel has chosen through a new technique. Then grow the region using existing region growing technique. The flowchart of the overall work is given in Fig. 7. The total procedure is described below.

a) *Seed Selection using New Technique*

In seeded region growing, the seed pixel should be selected before the regions grow. The seed selection procedure using the new technique is given below:

1. Consider the input image as one region.
2. Divide the total image region into three sub-region row wise and column wise respectively.
3. Calculate the summation of the pixels of each region both row wise and column wise.
4. Select a region where the summation of the pixels is maximum both row and column wise.
5. Select the seed pixel position manually from the selected region.

The following example shows the total process of seed position selection by selecting the region with maximum pixels value. Fig. 1(a) shows the pixels of original image, (b) shows the row wise division of the total image region, the summation of the pixel intensity values of each row wise sub-regions is shown in (c), (d) shows the selection of maximum valued sub-region from row wise calculation, where (e) shows the column wise division of total image region, the summation of the pixel intensity values of each column wise sub-regions is shown in (f), the selection of maximum valued sub-region from column wise calculation has shown in (g) and (h) shows the region which is selected finally after row and column wise selection. For growing the region a pixel's position has been selected for seed from the selected region.

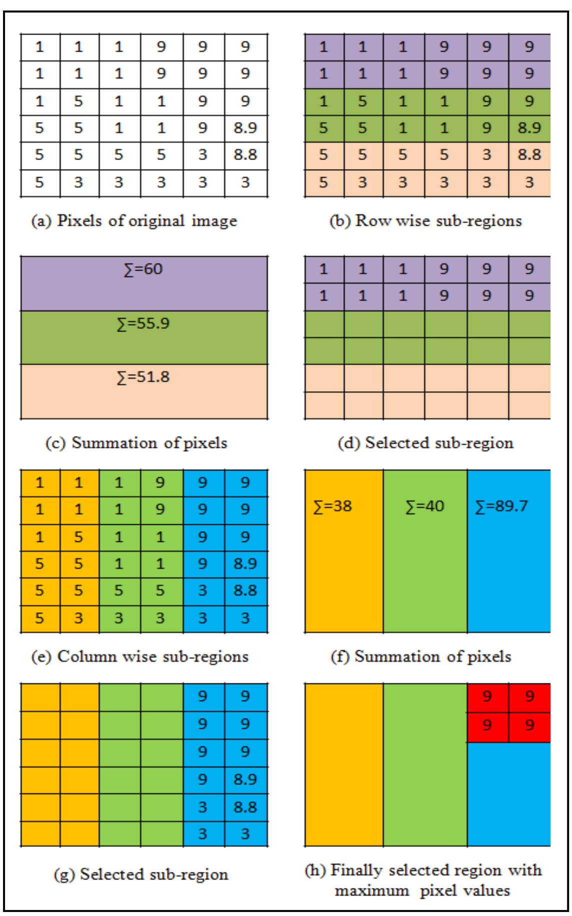

Fig.1: Seed pixel selection process

b) Set up Homogeneity Criterion

In region growing technique, the region growing depends on a homogeneity criterion which is used to set up the stopping rule. In the proposed method, the difference between a pixel's intensity value and the region mean (δ) is used for homogeneity criterion. If the value of δ is less than a certain threshold then the pixel is under consideration and added to the growing region otherwise excluded from consideration. For the threshold value 0.2 has to be used.

c) Region Growing Process

For the segmentation of the image the region growing process is described below through an example. Fig. 2(a) shows the pixel values of the smoothed image with the seed pixel. By using the homogeneity criteria the neighboring pixels of the initial seed points can be checked. If the neighbor pixel values met the homogeneity criteria, they can be added to the growing region. It is going on until the value of δ is less than a certain threshold, which is 0.2 for the proposed algorithm. To grow the region by growing the neighboring pixels the 4-connected neighborhood is used in proposed method.

d) Proposed Algorithm

The proposed algorithm mainly segments the foreground from an image. The algorithm works with spatial domain of the input image. The improved algorithm for single seeded region growing is shown in below:

Step 1: Smooth the input image using Gaussian filter.

Step 2: Select the seed pixel by the following steps:

a) Divide the smoothed image into three regions row wise and column wise.
b) Calculate the summation of the pixel intensities of each region separately for both row and column wise.
c) Find out the two maximum summation values from both row and column wise grouped region.
d) Select a pixel position from the maximum summation valued regions.

Step 3: Set up a stopping rule by selecting a certain homogeneity criterion.

Step 4: According to the criterion grow the region by adding similar neighbouring pixels.

Step 5: When no more pixels met the criterion stop growing for inclusion that region.

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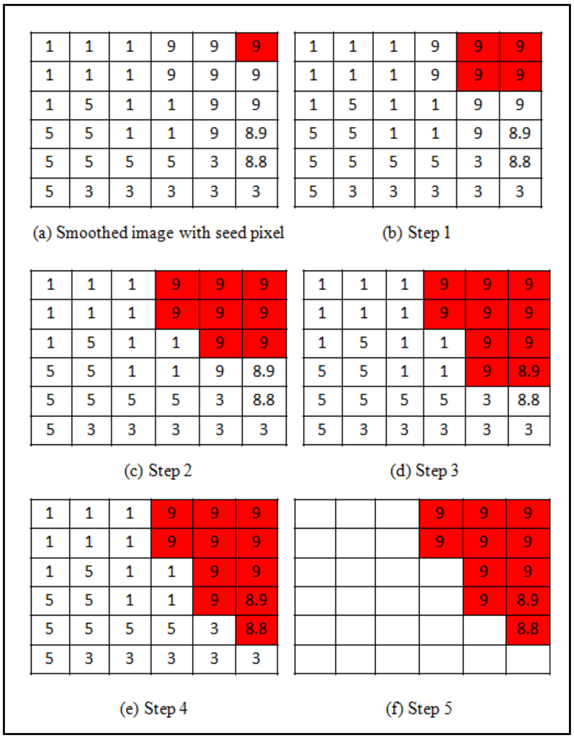


Fig. 2: Region growing process using proposed method

IV. Experimental Results and Analysis

Segmentation procedure becomes semiautomatic starting with an interactive seed point selection step, followed by the region growing process [12]. In this paper an image dataset is taken from *Berkeley Segmentation Dataset* [13] containing a set of images with training and corresponding ground truth images for experiment and performance evaluations. The objective evaluation can be performed using three performance evaluation parameters. Through these parameters it can be shown that the proposed method has better performance. For the performance evaluation we use several sample images. For the experiment, all the methods and algorithms are implemented in MATLAB 7.10.0 (R2010a) toolbox for processing the images.

a) Segmentation Evaluation Parameters

Yet a reliable way cannot be found in performance evaluation for quantitatively measure the state of different image segmentation techniques. In previous works, segmentation performance can be evaluated through subjectively or objectively judging on several sample images [16]. In this paper, three segmentation performance evaluation parameters have been studied. These are rand index (RI), global consistency error (GCE), and variations of information (VoI).

i. *Rand Index (RI)*

The greater the Rand Index value the better the segmentation is. The equation for rand index is as follows [16].

$$RI = \frac{a+b}{a+b+c+d} = \frac{a+b}{\binom{n}{2}} \qquad (1)$$

Where, a + b means the number of agreements between X and Y and c + d means the number of disagreements between X and Y.

ii. *Global Consistency Error (GCE)*

If the global consistency error value is smaller the segmentation performance is better. The equation for global consistency error (GCE) is as follows [16].

$$GCE = \frac{1}{n}\, min\left\{\sum_i E(S_1, S_2, pi), \sum_i E(S_1.S_2, pi)\right\} \qquad (2)$$

Where, segmentation error measure takes two segmentations S_1 and S_2 as input, and produces a real valued output in the range [0::1] where zero signifies no error.

iii. *Variations of Information (VoI)*

For the better segmentation performance of an image the variations of information should be low. The equation for variations of information is as follows,

$$VI(X;Y) = H(X) + H(Y) - 2I(X,Y) \qquad (3)$$

Where $H(X)$ is entropy of X and $I(X,Y)$ is mutual information between X and Y. VI(X,Y) measures how much the cluster assignment for an item in clustering X reduces the uncertainty about the item's cluster in clustering Y.

b) Analysis of the Experimental Result

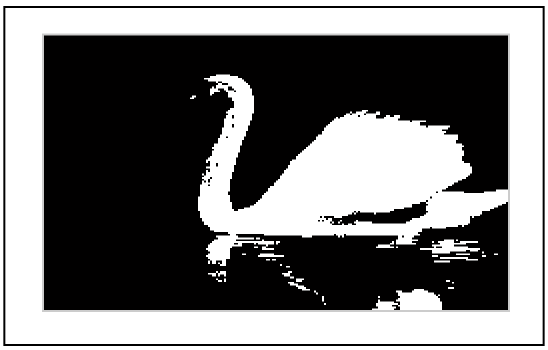
The segmentation result has been evaluated hrough two ways. These are *objective evaluation* and *subjective evaluation*. The comparisons between different segmentation techniques have shown in the Table 1, which is the objective evaluation. The subjective evaluation of the different segmentation techniques is shown in Fig.4. From the experimental result analysis and evaluation, it is concluded that the proposed algorithm has the best overall performance with the above mentioned parameters.

i. *Subjective Evaluation*

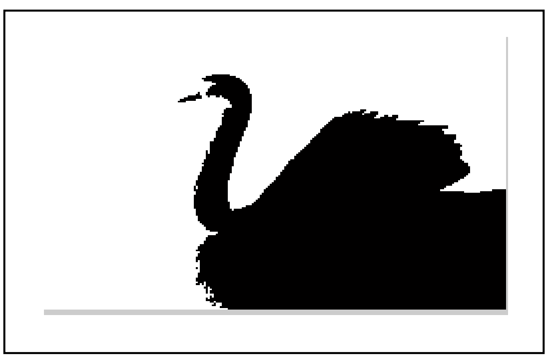
In this research, the subjective evaluation has been performed through the visual comparison of different types of segmentation algorithm. The comparison has been performed between the segmented images. Fig. 3 shows the original image, and Fig. 4(a)-(f) show the segmented images of the original image using different segmentation techniques with the proposed one.

The experiment is also done with noisy image. Fig. 5 shows the input image with noise. The output of different segmentation techniques with proposed one have shown in Fig. 6, where 6(c) shows the proposed method and rest show the other methods.

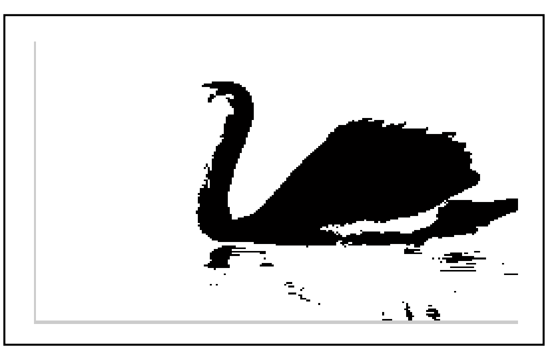
Fig. 3: Original Image



(a) Otsu's Thresholding

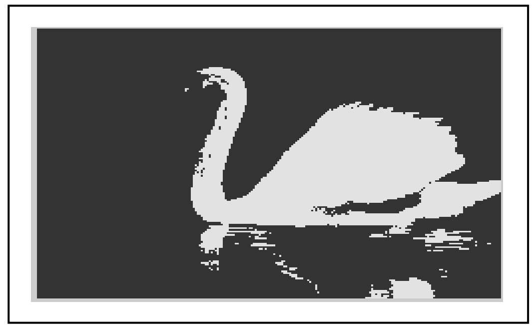


(b) Existing seeded Region Growing



(c) Proposed

(d) Watershed



(e) K-mean clustering

(f) Region Splitting and Merging

Fig. 4: Segmented images of the original image using different segmentation techniques and proposed algorithm

Table I : The Comparisons Between Different Image Segmentation Techniques

Parameters / Methods	Rand Index (RI)	Global Consistency Error (GCE)	Variation of Information (VoI)
Otsu's thresholding	0.54123	0.31011	2.11010
Existing Single seeded Region Growing	0.49996	0.30955	2.26006
Proposed	**0.54641**	**0.31005**	**2.08395**
Watershed	0.32012	0.30818	7.63398
K-mean Clustering	0.54167	0.31011	2.10854

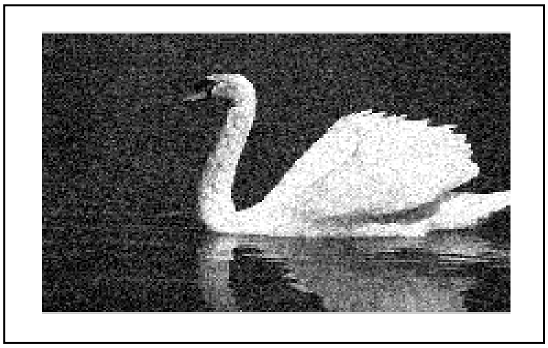
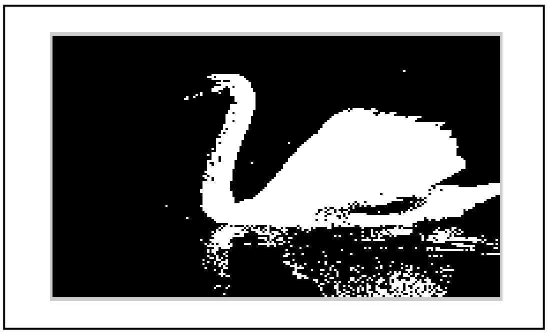
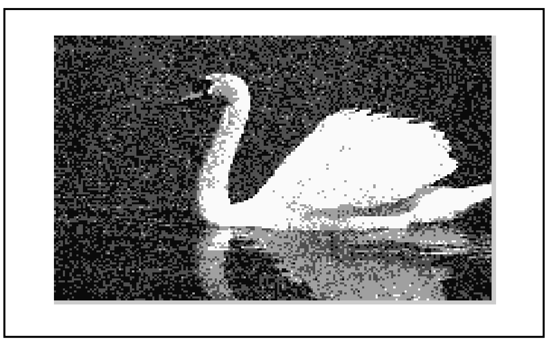


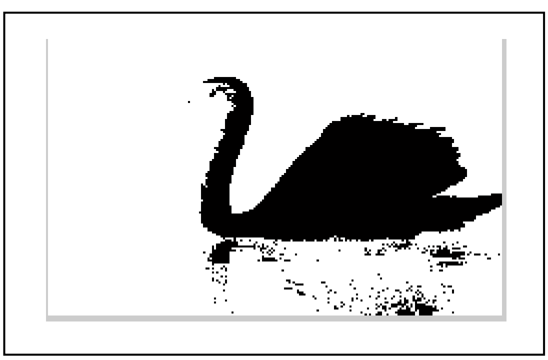
Fig. 5: Original Image with noise



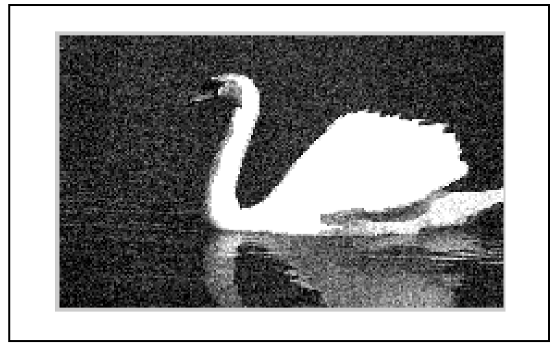
(a) Otsu's Thresholding



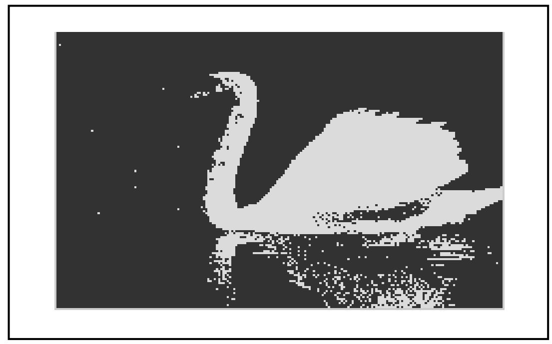
(b) Existing Seeded Region Growing



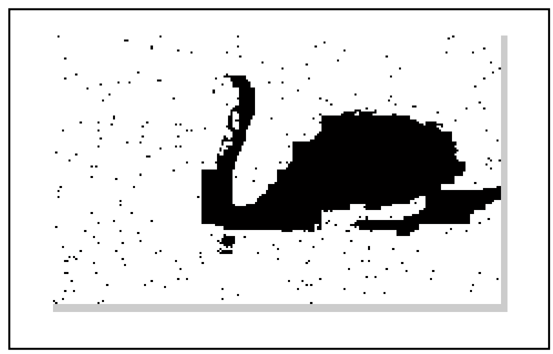
(c) Proposed



(d) Watershed



(e) K-mean clustering



(f) Region Splitting and Merging

Fig. 6: Segmented images of the noisy original image using different segmentation techniques and proposed algorithm

ii. *Objective Evaluation*

In this research, the objective evaluation has been performed using three segmentation evaluation parameters such as rand index, global consistency error, and variation of information. It is known that for the better segmentation performance the rand index should be high and the other two should be low. Table 1 shows the comparison of various segmentation techniques using the segmentation evaluation parameters. In the proposed method, it is seen that the segmentation evaluation parameters that is the rand index value is high, global consistency error value is low, and variation of information value is low than the other techniques.

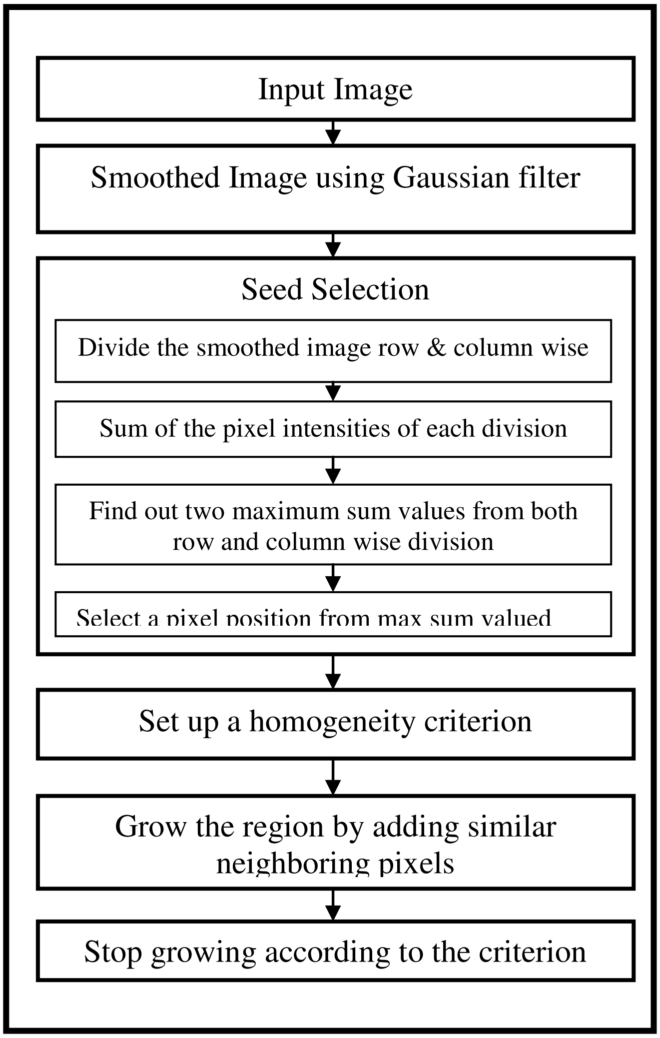


Fig. 7: The block diagram of the methodological steps of our research works

V. Conclusion

It is known that not all methods are equally good or efficient for a particular type of images and particular method is not good or efficient for all images. In this research, the images which background intensity value is less than the foreground intensity value are used for experiment. The proposed algorithm works with such kind of images efficiently. Since many researchers has been worked to form hybrid (combined two or more than two existing methods) methods for image segmentation, a hybrid method is described in this article; where the single seeded region growing algorithm is combined with proposed seed selection technique.

The performance of proposed algorithm is effective such kind of image which foregrounds pixel's intensity value is higher than the background. The proposed method is very similar to existing single seeded region growing exception with seed selection method. The experimental images has taken from the Berkeley Segmentation Dataset [13] containing a set of images with training and corresponding ground truth images.

From the investigation, it has been shown the efficiency of proposed method for segmentation is better than others. The proposed algorithm also works better with noisy image. The proposed region based method is efficient to identify the blood vessels in MRA and CTA volume data.

In future a hybrid method would be implemented by combining the K-mean clustering and multiple seeded region growing methods. The performance and efficiency may better than others.

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