A Novel Approach for Image Segmentation Enhancement through Multi-Region Clustering Technique

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Abstract: *Image segmentation has been, and still is, a relevant research area in Computer Vision, and hundreds of segmentation algorithms have been implemented in the last 30 years. However, it is well known that elemental segmentation techniques based on boundary or region information often fail to produce accurate segmentation results and efficiency. This paper focused on three segmentation techniques i. e Stochastic Random Walker Method, Reflection Symmetry, Spatially coherent Fuzzy Clustering Method, which integrates edge and region information to fuse such information. It is also useful for feature extraction, image measurements and image display but reduces speed, and efficiency. To improve the speed of processing drastically, improved image segmentation by exploiting image symmetry, gives reliability, preserve efficiency, so we propose Multi-region clustering algorithm (MRC). Segmentation using multi-region clustering can perform well in intersection areas in comparison with manual ones. The propose method can achieve satisfactory result.*

Keywords: Stochastic Random Walker Method, Reflection Symmetry, Spatially coherent Fuzzy Clustering Method

1. Introduction

The image segmentation is a key process of the image analysis and the image comprehension. Because of the influence of the complicated background, the object characteristics diversity and the noise, the image segmentation is the difficult and hot research issues on the image processing. The process of partitioning a digital image into multiple regions (sets of pixels) is called Image Segmentation. The need for segmentation to improve segmentation results. Actually, partitions are different objects in image which have the same texture or colour. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. All of the pixels in a region are similar with respect to some characteristic or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics. Some of practical applications of image segmentation are**:** image processing, computer vision, face recognition, medical imaging, digital libraries, image and video retrieval, etc.

This paper, discusses three methods i.e. Stochastic Random Walker Method, Reflection Symmetry, Spatially coherent Fuzzy Clustering Method. To improve the performance of the standard FCM algorithm and overcome the noise problem, integrate local neighbourhood information in spatially coherent fuzzy clustering method.

2. Background

The study on image segmentation discusses the most relevant segmentation techniques developed in recent years. In Stochastic Random Walker Method, the original random walker algorithm, there is no information about included uncertainties, although its name might suggest so. Instead, the name "random walker" is chosen because the direction of the random walk randomly chosen from probabilities based on the deterministic image gradient. In fact, error propagation is hard or even unfeasible for most of the image processing algorithms including the random walker method. A first attempt to include error propagation in random walker segmentation but it is able to prove theorems dealing with independent RVs only. That's why Based on stochastic PDEs (SPDEs), developed a method for error propagation in image processing, they identified pixels by RVs and called such images **stochastic images.** Discredited the RVs and the stochastic PDE by the method of generalized polynomial chaos, combining the recent developments in numerical methods for the discretization of stochastic PDEs and an interactive segmentation algorithm. This model is not sufficient for many applications, because correlated the noise and may depend on the gray value [1].

The overall segmentation performance is improved to compared with the regular region growing, and the improvement comes only from the integration of symmetry. The existence of symmetry can be measured as a binary (exists or not) or a continuous (variable) feature. The symmetry as a continuous feature, in which intermediate values of symmetry denote some intermediate amount of symmetry. Since symmetry in the real world is not perfect, it does not restrict the symmetry as a binary feature, where the object is either symmetric or non-symmetric. This paper has detected the discrete reflection symmetry axis of an image and it used a continuous symmetry magnitude to measure the amount of symmetry in an image. Based on the selection of a threshold for symmetry magnitude, the presence or absence of the symmetry axis can be detected. The region growing segmentation takes 87 percent of the total running time. But computational efficiency of this method is poor [2].

Lack of this efficiency, implemented a **spatially coherent fuzzy clustering Method.** The main drawback of the standard FCM algorithm is that it deals with image elements as separate points (without considering their spatial position

in the image) and thus, noisy elements are often wrongly classified. To improve the performance of the standard FCM algorithm and overcome the noise problem, integrate local neighbourhood information in this method. Furthermore, to obtain more accurate segmentation used phase congruency features to define isotropic or anisotropic neighbourhood configuration [3].

This paper introduces three segmentation methods i.e Stochastic Random Walker Method, Reflection Symmetry, Spatially coherent Fuzzy Clustering Method and these are organizes as follows. **Section I** Introduction. **Section II** discusses Background. **Section III** discusses previous work. **Section IV** discusses existing methodologies. **Section V** discusses attributes and parameters and how these are affected on images. **Section VI** proposed method and outcome result possible. Finally **section VII** Conclude this review paper.

3. Previous Work Done

In research literature, to improved noisy images, increase efficiency using recent techniques [1] [2] [3]. Image segmentation in real-world applications is typically performed on noisy images. The image noise depends on the image acquisition modality and extrinsic parameters. To get information about the error propagation, to generate input samples via the repeated acquisition of the same scene or via sampling from noise modelling. To avoid the repeated used of classical segmentation methods; segment the stochastic images until to get the stochastic information by stochastic random walker segmentation method. The result of the stochastic random walker segmentation on this stochastic image is again a stochastic image with the same number of basic RVs. Because a stochastic diffusion equation has to be solved in the random walker method, stochastic information was transported between the pixels. This method combines the advantages of a supervised segmentation algorithm with the propagation of information about gray –value uncertainty [1]. In symmetry region based image segmentation method, demonstrate the improvement of pixel level image segmentation by incorporating the high level symmetry cue. A new symmetry-integrated scheme has implemented for region-based image segmentation to improve its performance. This goal is achieved by incorporating symmetry into the region growing segmentation, in terms of the symmetry affinity matrix [2].

For accurate and noise-robust image segmentation novel FCM based method is implemented. This method has designed to accurately segment edges, lines and coarse homogeneous regions at the same time and integrate spatial contextual information of the neighbouring pixels into the FCM algorithm using phase congruency, anisotropic neighbourhood and adaptive weights for membership calculation. In this way, the new FCM method has designed to accurately segment edges, lines and coarse homogeneous regions at the same time [3].

4. Existing Methodologies

Many image segmentation methods have been implemented over the last several decades. There are different methodologies that are implemented for image segmentation

i.e Stochastic Random Walker Method, Reflection Symmetry, Spatially coherent Fuzzy Clustering Method.

The Stochastic Random Walker methodology used Generalized Spectral decomposition with random walker segmentation methodology. The extension of the random walker segmentation to stochastic images was straightforward and follows the methods for processing of stochastic images The edge weights for the graph are defined by the difference of two RVs, which describe the gray-value uncertainty for the corresponding pixels. End up with stochastic edge weights, which are RVs, i.e.

$$w_{ij}(\boldsymbol{\xi}) = \exp\left(-\beta\left(g_i(\boldsymbol{\xi}) - g_j(\boldsymbol{\xi})\right)^2\right)$$

This method for the computation of the exponential of a gPC quantity, along with methods for other computations such as multiplication, division, computation of square roots, etc., was developed. It is straightforward to generalize the notion of node degrees and the normalization step for the image gradient to stochastic images as follows:

$$d_i(\boldsymbol{\xi}) = \sum_j w_{ij}(\boldsymbol{\xi})$$

$$(g_i(\boldsymbol{\xi}) - g_j(\boldsymbol{\xi}))^2 = \frac{(u_i(\boldsymbol{\xi}) - u_j(\boldsymbol{\xi}))^2}{\max_{\{k,l \in V : e_{k,l} \in E\}} \mathbb{E}\left((u_k(\boldsymbol{\xi}) - u_l(\boldsymbol{\xi}))^2\right)}$$

In Reflection Symmetry Integrated Method, three different Methodologies for segmented regions of the image.

### 1) Discrete Reflection Symmetry Detection and the Symmetry Affinity Matrix

The reflection symmetry axis of an image is extracted by the global symmetric constellations of features. This algorithm is capable of finding a dominant symmetry axis when an image has one or multiple symmetric objects.

2) Symmetry-Integrated Region Growing Segmentation

The region growing starts the segmentation from initial seeds of pixels and agglomerates their neighbouring pixels having similar features to form uniform regions iteratively.

3) Segmentation Optimization

It is able to search the segmentation results with optimal performance for both segmentation and symmetry.
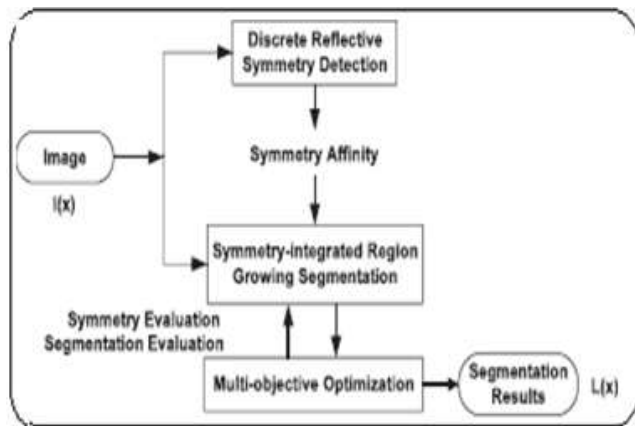
Figure 1: System diagram for symmetry-integrated image segmentation

Final Technique, Spatially Coherent Fuzzy Clustering Method. The FCM clustering algorithm has based on minimizing the following objective function:

$$J_m = \sum_{i=1}^{C} \sum_{j=1}^{N} u_{ij}^m D_{ij},$$

The main drawback of the standard FCM algorithm, it deals with image elements as separate points (without considering their spatial position in the image) and thus, noisy elements often wrongly classified. To obtain more accurate segmentation, used phase congruency features to define isotropic or anisotropic neighbourhood configuration.
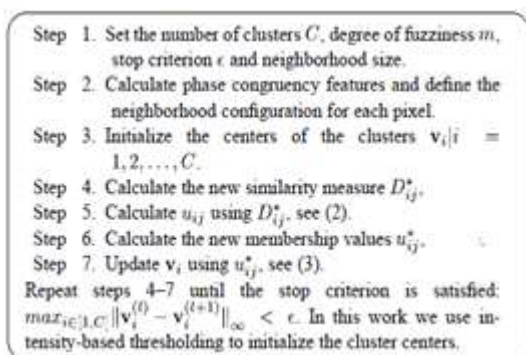
Algorithm 1: Outline of Robust FCM Algorithm

5. Analysis and Discussion

In many applications, the noise of pixels in the image is independent from the noise of the neighbouring pixels. It has possible to model this kind of stochastic images with the presented approach as well. To demonstrate the possibility of modelling such kind of images, use an artificial test example, i.e., a "doughnut" with an area of 60 pixels in front of a constant background with a resolution of 20 pixels. Corrupt the image by uniform noise and treat the noisy image as expected value of the stochastic image. This modelling was close to the situation in real applications. There, the real noise-free image not available, and thus, the sample at hand is the best available estimate of the expected value. Due to the high number of basic RVs, restrict the polynomial chaos to a degree of 1, i.e., able to capture the effects expressible in uniform RVs only. Used a polynomial degree of order 1, the polynomial chaos has coefficients per pixel. Used a polynomial degree of 2, end up with coefficients. Contemporary personal computers cannot store such a high number of stochastic modes. A solution can be the usage of sparse polynomial chaos expansion, but this has to be further investigated in subsequent work. After the initialization of the expected value with the noisy input image, to prescribe values for the remaining chaos coefficients of the input image. As assume the noise at every pixel to be independent from the noise at other pixels, to prescribe a value for the coefficient corresponding to the basic RV of the pixel. Set this coefficient to, modelling a uniform distributed RV with support around the expected value given by the noisy input image [1].

Reflection Symmetry method aims to improve the region growing segmentation by integrating the symmetry cue, used the symmetry affinity matrix region growing concerns the aggregation of a region by its neighbouring pixels having similar properties measured by the homogeneity criteria, based on colour, texture, shape, etc. The region homogeneity criterion $\delta_R(p_i, r_j)$, was given by

$$\delta_R(p_i, r_j) = W_{Color}\, \delta_{Color}(p_i, r_j) + W_{Texture}\delta_{Texture}(p_i, r_j),$$

Where $W_{Texture} + W_{color}=1$ The weights W_{colour} and $W_{Texture}$ could be allocated in a dynamic manner, depending on whether a region shows more uniformity in colour or texture, as described in the dynamic weights allocation with the region growing algorithm. Initial segmentation by the aggregation criterion $\delta(p_i, r_j)$ is an over segmented result. During the region merging, neighbouring regions has merged using the criterion

$$m(r_i, r_j) = \|F_{Color}(r_i) - F_{Color}(r_j)\| + \|F_{Sym}(r_i) - F_{Sym}(r_j)\|,$$

Which are the Euclidean distances of mean colour and mean symmetry affinity values of two regions r_i and r_j [2]. In spatially coherent fuzzy clustering method, if $\alpha = \beta = 0,$, the standard FCM algorithm. If $\alpha = \beta = 1$, the neighbourhood attraction was maximal and it decreases for $\alpha < 1$ or $\beta > 1$. The optimal values of α and β depend on the image noise level because of only important neighbours used to calculate the weights and the best segmentation has achieved when the neighbourhood attraction was maximal [3].

Table 1: Comparisons between Stochastic RWM, Reflection Symmetry, Spatially Coherent Fuzzy Clustering

Segmentation Techniques	Advantages	Disadvantages
Stochastic Random Walker Method	1) It gives a reliable result. 2) It allows determining the Probability density function of the segmented Object volume.	The stochastic collocation methods suffer from the "curse of dimension", because the execution times exponentially grow with the number of RVs.
Reflection Symmetry	1) Global symmetry detection. 2) Robust to distortions global symmetry detection & symmetry as a continuous feature that is more robust to distortions.	The Reflection Symmetry method highly depends on the symmetry axis detection.

Spatially Coherent Fuzzy Clustering	Accurate and noise-robust image segmentation	The main drawback of the standard FCM algorithm is that it deals with image elements as separate points (without considering their spatial position in the image) and thus, noisy elements are often wrongly classified.

6. Proposed Methodology

Many clustering strategies have been used, such as the crisp clustering scheme and the fuzzy clustering scheme, each of which has its own special characteristics. Among the fuzzy clustering methods, fuzzy C-means (FCM) algorithm is the most popular method used in image segmentation because it has robust characteristics for ambiguity and can retain more information than hard segmentation methods. Clustering algorithms are used for segmenting Digital images however noise are introduced into images during image acquisition, due to switching, sensor temperature. The segmentation techniques have some limitations for reliability, efficiency and accuracy. So we propose Multi-region Clustering (MRC) to preserve efficiency, improve reliability and more accuracy. The Multi-region Clustering (MRC) method estimates the number of regions in the image in an unsupervised fashion. The effectiveness of the propose MRC method by using synthetic and real data. The propose MRC algorithm not only estimate the appropriate number of region but also can get better segmentation quality, in compare with existing multi-resolution segmentation methods. MRC method will be implemented to ensure both types of centers or regions are continuously updated in every iteration till up of the pixels assigned to the fitting region.
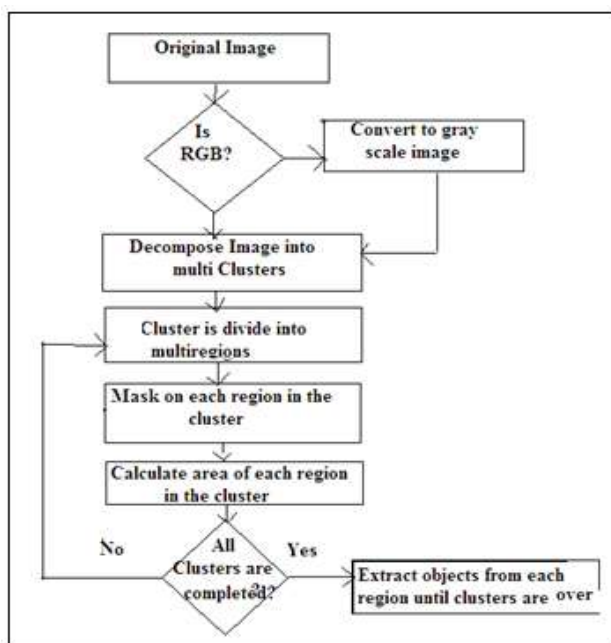

Figure 2: Multi-region Clustering Technique

6.1 Outcome Possible Result

The robustness of the extracted features can be used in a multi-region clustering method which aims at determining the homogeneous Regions. The proposed method will have successfully increase accuracy in segmentation process and achieve satisfactory results and also identify number of objects belongs in particular region. Segmentation by using multi-region clustering can perform well in intersection areas in comparison with manual ones.

7. Conclusion

This paper focused on the study of different segmentation techniques i.e Stochastic Random Walker Method, Reflection Symmetry, Spatially coherent Fuzzy Clustering Method. The performance of the different algorithms over the set of synthetic images can be extrapolated to the results obtained over real ones. However, the outputs of these methods can be regressed with more objective variables, which provide the best performance according to the simplicity of the algorithm and the accuracy of the results. The proposal of multiregional- clustering algorithm (MRC) improves efficiency. The segmentation methods mostly used in Medical applications, Digital camera, magnetic resonance, computed tomography (CT), Detection of accuracy such as unman aerial vehicle landing mark and flights, also verify this point, real-time target recognition, Face detection, Human tracking and Identification and Image Pattern Detection, Human tracking and Identification and Image Pattern Detection.

8. Future Scope

From Observation, the scope and planned to be studied in future work, the propose algorithm are more suitable for segmentation of natural images without a prior knowledge about the content in the computer vision applications and also will focus on the divide clusters into blocks for faster segmentation and for reduced computation time.

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