Techniques in Image Segmentations, its Limitations and Future Directions

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Abstract—There many techniques, used for image segmentation but few of them face problems like: improper utilization of spatial information. In this paper, combined fuzzy c-means algorithm (FCM) with modified Particle Swarm Optimization (PSO) to improve the search ability of PSO and to integrate spatial information into the membership function for clustering is used. Here, in this paper discussion on segmentation techniques with their limitations is done. This would help in determining image segmentation method which would result to improved accuracy and performance.

Keywords-*fuzzy c-means (FCM), segmentation, Particle Swarm Optimization (PSO), spatial, membership function*

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I. INTRODUCTION

Images are one of the most important means of transmission of information in the field of computer vision, by understanding images the information extracted from them can be used for other tasks for example: navigation of robots, extracting malign tissues from body scans, detection of cancerous cells, identification of an airport from remote sensing data, satellite data analysis, geographical structure analysis etc. There is a need of a method, with the help of which, we can understand images and extract information or objects. So image segmentation, which is the first and the important step in image analysis, realizes the aforementioned requirements.

Image segmentation is the process of partitioning an image into multiple segments, so that the changes in the representation of an image can be converted into something that is more meaningful and easier to analyze. The basic objective of image segmentation is to classify the pixels of a given image into two classes: those pertaining to an object and others pertaining to the background. While one includes pixels with gray values that are below or equal to a certain threshold, the other includes those with gray values above the threshold [1].

An image can be represented in different feature spaces and what the Fuzzy C-Mean (FCM) algorithm does is that it classifies the image by forming a group of similar data points in the feature space, called as clusters. Now this process of clustering is accomplished by iteratively minimizing a cost function that is reliant on the distance of the pixels to the cluster centers in the feature domain [9].

Particle swarm optimization (PSO) is a very recent proposed population-based stochastic optimization algorithm which is inspired by social behavior of animals i.e. fish schooling and bird flocking [5]. PSO performs better or even superior in searching many hard optimization problems with faster and more stable convergence rates [8] [6]. PSO has been used in different industrial areas such as power systems, parameter learning of neural networks, control, prediction and modelling, etc. However, observations reveal that PSO converges sharply in the early stages of the searching process, but after a while it saturates or even terminates in the later stages. It behaves like other traditional local searching methods which get trapped in local optima. As a result of this, it is hard to obtain any significant improvements by examining neighboring solutions in the later stages of the search [7].

In order to improve accuracy of segmented images, in this paper the images will be efficiently segmented into number of clusters. Different images from different domain will be considered for the experiment. By using fuzzy clustering algorithm, different centroids will be obtained, which are used to find different clusters. Later these clusters will be fine-tuned by using PSO algorithm.

II. LITERATURE REVIEW

A. N. Benaichouche, H. Oulhadj and P. Siarry [2] haveproposed a multi objective optimization approach which is based on grayscale image segmentation method that improves twocomplementary criteria (region & edge based).The proposed approach had two steps. The recognitionof high-confidence points is done through finding out the similarity between the outcomes and membership degrees in the first step. In the second step, the classification of the points that were left out is done by utilizing the highconfidenceextracted points. Synthetic images, simulatedMRI brain images & real-world MRI brain images were considered and assessed in the proposed approach. Comparison between the most commonly used FCM-based algorithm is done and the results from given technique are been demonstrated to reflect the efficiency.

Z. Ji, J. Liu, G. Cao, Q. Sun, and Q. Chen [3]haveproposed the Robust Spatially Constrained Fuzzy C-Means (RSCFCM) algorithm which uses negative logposterioras dissimilarity function, presented as a new factor and the bias field estimation model is incorporated into fuzzyobjective function. The proposed technique effectively overcomes the shortcomings of existing FCM-type clustering methods and EM-type mixture models. The proposed method can beat the challenges produced bynoise & bias fields, which is demonstrated through statistical result(mean & standard deviation of Jaccard similarity for every tissue) of both synthetic and clinical images and also it demonstrates more than 5% of improved accuracy in segmentation of an image when compared with different algorithms.

B. N. Li, C. K. Chui, S. Chang, and S. H. Ong [4] haveproposed another fuzzy level method which is used to simplify segmentation of medicalimages. The method described in the given approach has the capability to directly progressfrom the initial segmentation through spatial fuzzy clustering.With the help of the outcomes of fuzzy clustering, controlling parameters of the level set evolution have beenassessed and also fuzzy level set method is improved by means of locally regularized evolution. Such kind of enhancements enables levelset manipulation & result in more robust segmentation. The estimation of performance foe the proposed method is doneon medical images from diverse modalities. Theviability for segmentation of medical images is demonstrated through results of the proposed method.

A. N. Benaichouche, H. Oulhadj, and P. Siarry [5] haveproposed an enhancement technique for image segmentationutilizing the fuzzy c-means clustering algorithm (FCM).At three diverse stages the proposed technique works. In the initial step the fuzzy c-means algorithm improves itselfthrough enhancing the initialization stage by utilizing a Metaheuristic optimization. The incorporation ofthe spatial gray-level information about the image in theclustering segmentation procedure and the utilization of Mahalanobis distance which decreases the impact of the geometricalshape of the dissimilar classes has been carried out in the second stage. The last level was related to refining the outcomes of segmentation by fixing the faults of clustering through reallocating thepotentially misclassified pixels. The proposed technique calledas improved spatial fuzzy c-means IFCMS, has been assessed on both synthetic images and simulated brain MRI images from the McConnell BrainImaging Center (Brain Web) database and on few test images as well. The comparison with the maximum used FCM-basedalgorithms of the literature is done in the proposed technique. Theeffectiveness of the ideas presented have been demonstrated through outcomes.

Arunava De, Anup Kumar Bhattacharjee, Chandan Kumar Chanda and Bansibadan Maji [15] have proposed a hybrid particle swarm optimization algorithm that incorporates Wavelet theory based mutation operation is used for segmentation of Magnetic Resonance Images. In the proposed approach they have usedEntropy maximization using Hybrid Particle Swarm algorithm with Wavelet based mutation operation to get the region of interest of the Magnetic Resonance Image. In order to enhance particle swarm optimization algorithm, later they have applied the Multi-resolution Wavelet theory in exploring the solution space more effectively for a better solution. Tests on various MRI images with lesions demonstrate that lesions are successfully extracted.

Yangyang Li,Yang Yue, Licheng Jiaoand Ruochen Liu [16] have used Quantum-behaved particle swarm optimization (QPSO) algorithm simulates quantum mechanics among individuals. To make the local search ability of QPSO better and guiding the search, an improved QPSO algorithm based on combining the dynamic mutation and cooperative background (MCQPSO) is proposed. In order to enhance the global search ability the dynamic Cauchy mutation strategy is been introduced. The MCQPSO algorithm keeps the diversity of the population, and increasing convergence rates. The outcomes are compared with some previous study show that the MCQPSO algorithm performs way better than the Sun Jun’s Cooperative Quantum-Behaved Particle Swarm Optimization (sunCQPSO) and WQPSO algorithm in terms of the image segmentation accuracy and the computation efficiency.

Saeed Mirghasemi, Ramesh Rayudu and Mengjie Zhang [17] have proposed a method in which basic version of PSO is used in combination with a new modified seeded region growing (SRG) algorithm. In the described approach the seeded region growing algorithm tackles three problems faced during the use of simple region growing: the position of seeds, the number of seeds, and region growing strategy. Two new versions of SRG are introduced here to solve the multi seeded region growing problem, and also region growing strategy. Then Particle Swarm Optimization is utilized to solve the localization problem. The test results show that the proposed method is successfully applied to gray scale image segmentation.

Dunguang Zhou, Yichun Xu and Fangmin Dong [1] have used an interactive segmentation tool, livewire, which can extract the boundary of a region with a mouse. The segmentation is based on the features of the pixels in the image. In the livewire approach, used in earlier days had the features have been assigned with fixed weights. But in this given approach a learning phrase is designed before segmentation where the particle swarm optimization (PSO) is applied to find more suitable weights. To make the PSO perform better, initialization of the population are special designed, the iteration and the convergence are visualized, and the start and stop of PSO are human-controlled. Experimental results show that the PSO learning livewire has better performance than the livewire with fixed feature weights.

III. DIFFERENT METHODS OF IMAGE SEGMENTATION

There are many categories for segmentation described in literature. Let us get a gist of these techniques:

1. Thresholding:

In thresholding, pixels are allocated to categories according to the range of values in which a pixel lies. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image. The key of this method is to select the threshold value (or values when multiple-levels are selected). Pixels with values less than threshold are been placed in one category, and the rest have been placed in the other category.

Given a single threshold, *t*, the pixel located at lattice position (*i*, *j*), with greyscale value f_{ij} , is allocated to category 1 if

$$f_{ij} \leq t$$

Otherwise, the pixel is allocated to category 2. In many cases *t* is chosen manually, by trying a range of values of *t* and seeing which one works best at identifying the objects of interest. Segmentation through thresholding has fewer computations compared to other techniques. The drawback of this segmentation technique is that it is not suitable for complex images.

2. Edge-based segmentation:

Edges typically correspond to points in the image where the gray value changes significantly from one pixel to the next. Thus, detecting edges help in extracting useful information characteristics of the image where there are abrupt changes. Edges are detected to identify the discontinuities in the image. Edges on the region are traced by identifying the pixel value and it is compared with the neighboring pixels. For this classification they use both fixed and adaptive feature of Support Vector Machine (SVM).

There are many methods of detecting edges; the majority of different methods may be grouped into these two categories:

A. Gradient:

The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. For example Roberts, Prewitt, Sobel and Canny operators detect vertical and horizontal edges. Sharp edges can be separated out by appropriate thresholding.

B. Laplacian:

The Laplacian method searches for zero crossings in the second derivative of the image to find edges e.g. MarrHildreth, Laplacian of Gaussian etc.

3. Feature based clustering:

Clustering is one of the important technique for segmentation. They followed a different procedure, where most of them apply the technique directly to the image but here the image is converted into histogram and then clustering is done on it [13]. Pixels of the color image are clustered for segmentation using an unsupervised technique Fuzzy C. This is applied for ordinary images. If the image is noisy, it results to fragmentation.

A general clustering algorithm i.e., K-means is used for segmentation in textured images. It clusters the related pixels to segment the image. Segmentation is done through feature clustering and there it will be changed according to the color components. Segmentation is also purely depending on the characteristics of the image. Features are taken into account for segmentation. Difference in the intensity and color values are used for segmentation.

For segmentation of color image they use Fuzzy Clustering technique, which iteratively generates color clusters using Fuzzy membership function in color space regarding to image space. The technique is successful in identifying the color region. Real time clustering based segmentation. A Virtual attention region is captured accurately for segmentation. Image is segmented coarsely by multithresholding .It is then refined by Fuzzy C-Means Clustering. The advantage is applied to any multispectral images.

4. Region based segmentation:

Where an edge based technique may try to explore the object boundaries and then discover the object itself by packing them in, a region based method takes the opposite approach, by (e.g.) beginning in the inside of an object and then “growing” outward until it encounter the object boundaries [14].

While in the region-based segmentation, pixels corresponding to an object are grouped together and marked. It also requires the use of appropriate thresholding techniques. The important principles are usefulness similarity (which have gray value differences and gray value variance) and spatial proximity (which consists of Euclidean distance and compactness of a region).

Segmentation algorithms based on region mainly include following methods:

A. Region Growing:

This is an ability for removing a region of the image that is connected based on some predefined criteria. This criterion is based on intensity information. Region growing is an approach to image segmentation in which neighboring pixels are examined and joined to a region class of no edges are detected. This process is iterated for severally boundary pixel in the region.

B. Region Splitting and Merging:

This technique works on the complete image. Region splitting is based on top-down approach. It appears with a complete image and splits it up such that the segregated sliced are more homogenous than the total. Splitting single is insufficient for sensible segmentation as it severely limits the shapes of segments. Hence, a merging phase after the splitting is always desirable, which is termed as the split- and-merge algorithm. Any region can be split into sub regions, and the appropriate regions can be merged into a region. Rather than choosing kernel points, user can divide an image into a set of arbitrary unconnected regions and then integrate the regions in an attempt to serve the shapes of rational image segmentation.

IV. PROBLEM FORMULATION

The entire image segmentation task is divided into following plan of actions:

1. Image Acquisition: Finding suitable data sets for experiments
2. Studying and applying FCM algorithm to find suitable clusters
3. Studying and applying modified PSO algorithm to segment the image
4. Applying the proposed method on selected dataset.

The first step in image segmentation is to identify centroids for image segmentation. Fuzzy c-means (FCM) is a clustering method that permits one bit of data to be in the right position to two or more clusters. FCM begins with a starting guess for the cluster centers that are suggested to spot mean location of every cluster. Also, FCM allots each data point a membership rank for every cluster. FCM repeatedly shifts the cluster centers towards the correct place inside a dataset through repeatedly updating the centers of the cluster & the membership grades for every data point.

This repetition is based on minimizing an objective function that symbolizes the distance from any given data point to a cluster center weighted by that data point's membership rank. Particle swarm Optimization (PSO) is also one of the optimization method, which finds its solution by iteratively moving in the search space. Here it finds it solution to cluster the image into different segments. The main aim of the PSO is to find better centroid for further segmentation.

Algorithm will be compared with different variants like:

1. By using simple k means algorithm without PSO
2. By using PSO only
3. By using Fuzzy C- means algorithm only

Figure 1: sample image segmentation results

V. CONCLUSION

In this paper FCM is integrated with particle swarm optimization to fine tune the centers of clusters obtained. The PSO algorithm used will be proposed as a modified particle swarm optimization algorithm applied to segment the images from different domain. The proposed algorithm will overcome the shortcomings of FCM which initially searches the centroid of clusters, which are erroneous and can also improve the calculation speed of the FCM algorithm, the partition efficiency and the quality of image segmentation.

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