APPLICABILITY OF GENETIC ALGORITHMS IN IMAGE SEGMENTATION

[1]Ketna Khanna, [2]Esha Khanna
[1]M.Tech Scholar, [2]Assistant Professor
[1]Computer Engineering
[1]J.C. Bose University of Science and Technology, YMCA
Faridabad, Haryana India.

Abstract : Image Analysis is a process of extraction of information from a given image. Image Segmentation partitions the image and segregates the important areas of the image. Image segmentation is an important task in Image Analysis as it helps in extraction of required information from a segmented image. Genetic Algorithms (GA) is a soft computing technique which can find optimal solutions for complex problems and can produce better results. A Literature review of proposed Image segmentation techniques have been presented. The paper also discusses applicability of Genetic Algorithms (GA) in Image Segmentation. It paves the way of GA in Image Segmentation.

***IndexTerms* – Image Segmentation, Genetic Algorithms, Image Segmentation Techniques.**

I. INTRODUCTION

Image segmentation refers to the splitting up of an image into a set of distinct regions that cover it [1]. An image is partitioned according to some attributes like pixel intensity or textural properties [2]. Image segmentation plays an important role in Image Analysis Process as its aim is to represent relevant areas of an image.

Image segmentation can improve pictorial information for human interpretation. It might prove helpful to analyse the image in computer and provide an easy and systematic future analysis and inspection of relevant areas [1]. Accuracy of segmentation can determine the eventual success or failure of computerized analysis procedure [3].

The initial foundation of Image segmentation was led by Lawrence Roberts in 1963. In order to detect edges of objects present in an image, the first edge detector was presented by Lawrence Roberts in 1965. It was named after the inventor, hence it was called Roberts operator or Roberts edge detector. It was initially used for partitioning the components of the image [4].

The work reviews various Image Segmentation techniques. A Genetic Algorithms

(GA) is a heuristic search method used in artificial intelligence and computing [5]. It is used for finding optimized solutions to search problems based on the theory of natural selection and evolutionary biology [6]. . It is an evolutionary algorithm that is capable of generating high quality optimized solution for complex problems [6].

GA are excellent for searching through large and complex data sets. The work also reviews the work done in Image Segmentation via GA. The review has been carried out using the guidelines of B. Kitchenham [7].

Goals of the paper are as follows

1. To review existing Image Segmentation techniques.
2. To discuss applicability of GA in Image Segmentation.
3. To pave the way of GA in Image Segmentation.

The organization of the paper is as follows, Section II discusses Literature review of Image Segmentation Techniques, section III discusses GA, section IV discusses applicability of GA in Image segmentation and section V concludes.

II. REVIEW OF IMAGE SEGMENTATION TECHNIQUES

A Review of Image Segmentation techniques have been discussed below:
Image Segmentation can also be termed as an operation wherein pixels with similar attributes are identified and grouped within same segment [8]. Image Segmentation is a process of decomposing an image into sets of regions according to some attributes like pixel intensity or textural properties [9]. The main aim of image segmentation is to segregate the relevant or meaningful areas or objects present in the image for further inspection.
Many image segmentation methods have been reviewed. Some of them are described as below:

Brzoza A et. al introduced an unsupervised approach for image segmentation based on the shortest paths in a graph representation of images. This work proposes characterization of pixels in images so as to give the similarity relation between them. Experiments prove that the proposed approach gives superior results as compared to other baseline methods of image segmentation [10].

Akinina A et. al. proposed a method for automatic segmentation as part of the pattern recognition algorithm for satellite images [11]. From analysis, the operability of the proposed method comes out to be good.

Li Y et. al proposed an improved version of grab cut algorithm which is the combination of grab cut and graph-based image segmentation [12]. From experiments, it has been proved that the proposed algorithm is effective and accurate.

Wilhelm T et. al., in their work [13] proposed an unsupervised bayesian segmentation method that comprises of the edges present in an image as part of the model. The proposed method produces encouraging results in comparison to supervised methods.

Sui H et. al. described a novel stable shape feature-based image registration method via matching the stable region with a set of rotations [14]. The proposed algorithm is not sensitive to rotation and resolution distortion, through which image registration can be accomplished automatically.

Zhang R et. al. proposed a segmentation algorithm based on Markov Random Field and Bayesian theory [15]. An objective function is also deduced in image segmentation problem on the basis of optimality criterion of statistical decision and estimation theory. The proposed algorithm is proved effective and robust.

Meinhold R et. al. proposed two improvements in the algorithm for computing piecewise flat embeddings (PFE), so as to reformulate portions of the algorithm to enable various linear algebra operations to be performed in parallel [16]. An iterative linear solver so as to quickly solve a linear least-squares problem is utilized. The tests reveal a significant drop in the execution time of proposed algorithm in comparison to other algorithms.

Since it is difficult to initialize contour properly in images of complex contents, Xu W et. al. have proposed an ensemble strategy so as to improve the contour-based segmentation [17]. The proposed algorithm is proved effective from experiments.

Robust segmentation algorithm on remote sensing images has been proposed and properly implemented by Krishna T et. al. [18]. The proposed approach displays good performance in terms of time, noise and over segmentation in comparison to the traditional segmentation techniques.

Ahmadi S et. al. presented an approach to extract support relation under the improvement of image segmentation approach [19]. The proposed approach gives encouraging results in terms of accuracy.

Felzenszwalb P et. al. described an object detection system which is based on mixtures of multiscale deformable part models [20]. Their system depends on new methods for discriminative training of classifiers which uses latent information. Proposed system is efficient as well as accurate.

Levin A et. al. proposed an approach based on supervised learning which is a combination of top-down and bottom-up cues in a principled manner [21]. Proposed approach is capable to efficiently search over thousands of candidate fragments.

Munoz X et. al. reviewed various segmentation techniques which integrate edge information and region information [22]. Highlights of different strategies and methods are described. Advantages and disadvantages of the various approaches are presented.

Chen PC. et. al. proposed an approach which uses global information to reach the ambiguous regions and uses the curve-fitting method to find the approximate boundary [23]. The proposed algorithm is not sensitive to the local samples and gives encouraging results.

In this paper a Pixel-Training Image-Testing (PTIT) algorithm for joint object segmentation and classification has been proposed by Ma Y. et. al [24]. From results it is clear that proposed algorithm reduces the time required for labeling and can handle more complex scenes.

Riza B. S. et. al. have presented a system that identifies the bacillus tuberculosis in the tissue slide images [25]. The thresholding method is used to stain neelsen zelshl fluid. The existing image is first converted to YIQ color and for each color, a histogram is displayed so as to identify the bacillus in the slide image. This study marks each bacillus in the slide image network with yellow which indicates a result in the slide. From analysis it is revealed that the proposed system can generate better image recognition and better segmentation in less time.

Tsuichihara S. et. al. have introduced a farm management system which recommends the plans which removes the broad-leaved weeds and finds out places where fertilizers are needed [26]. Farm management includes lowering the costs of labor, seeds and fertilizers so as to encourage breed raising cows and keeping the status of grass. The presented system was capable of detecting broad-leaved weeds with an accuracy of about 80%. The spread of diseases could be prevented by finding a grazing herd from the GPS data. The system was found effective.

Saxena X. et. al. have tested an automatic image segmentation procedure by applying some evolutionary meta-heuristic algorithms like ISA, CSA and BA on noisy images [27]. The idea is to maximize the threshold value where inter-class variance of the two classes of image pixels is found. To incorporate noise in the images, Gaussian noise was included with specific variance. The results of presented approach are then compared to the traditional iterative Otsu Method. It can be viewed from the convergence plots that ISA has faster convergence. The value secured by ISA is not always finer than that of CSA. Hence CSA can provide better accuracy but ISA has superior speed. CSA's overall performance of segmentation is better than other techniques while Otsu gives accurate results in less time.

Sourati J. et. al. have presented a new Active Learning (AL) method based on Fisher Information (FI) for CNN models. The proposed method is evaluated for brain extraction with a patch-wise segmentation CNN model in two learning scenarios which are Universal active learning and active semi-automatic segmentation [28]. Here the initial model was acquired with the help of labeled training subjects of initial data set. Target was to create a model which can perform well on the choosen subject. The proposed technique produces promising results. However there exists some obstacles in implementation of FI based AL. Computational complexity of the SDP is a major difficulty.

Jia H. et. al. have suggested a novel algorithm SAMFO-TH from MFO to improve the ability of segmentation [29]. In the proposed work, multilevel thresholding has been considered as the optimization problem for color image segmentation in which Otsu's between class variance and Kapur's entropy criteria have been utilized as objective functions. Thresholding heuristic is included in MFO so as to raise the global performance in Multilevel thresholding. The proposed technique is applied on various natural and satellite images. CPU Time, MVTR, STD, PSNR, MSE, SSIM, FSIM, PRI, VoI, and TVD are used as criteria to evaluate the performance. The proposed method is proved superior in terms of stability and accuracy. It produced better results than MFO.

III. GENETIC ALGORITHMS

A Genetic Algorithm (GA) is a soft computing technique which mimics natural selection and belongs to the larger class of Evolutionary Algorithms (EA) [30]. Soft Computing is a combination of various methodologies which are capable of finding the global optimal solutions to real world problems [6]. These techniques are used when the conventional techniques fail to provide solution for complex, intractable and ambiguous problems [31]. There are various soft computing methodologies like Neural Networks (NN), Genetic Algorithms (GA) and Ant Colony Optimization (ACO) [32].

GA was first introduced by John Holland in 1960 on the basis of the concept given by Darwin in his theory of evolution. It was then extended by his student David E. Goldberg in 1989 [33]. It belongs to the category of those techniques which solves optimization problem. The start population is generated either randomly or by using some automated methods like Greedy Algorithm. Population consists of finite candidate solutions whose number is selected prior to the start of execution. Through the process of GA, the initial population is evolved towards better solution.

IV. REVIEW OF GA BASED TECHNIQUES IN IMAGE SEGMENTATION

Many Image Segmentation techniques based on GA have been reviewed. Some of them are described as below:

Wang Y. proposed a new segmentation technique based on OTSU method and GA to obtain better segmentation results of infrared images [34]. Analysis shows that more stable threshold range is obtained and its calculation time is also minimized. Proposed method provides encouraging results.

A GA based image segmentation technique for medical images is proposed by Xiao-wei G. et. al. where largest variance between clusters is selected as the fitness function [35]. From experiments, it is proved that good segmentation results can be achieved with improved efficiency through proposed approach.

The work by Jin-Yu Z et. al. proposed an enhanced image segmentation technique for thermal images based on chaos- GA [36]. Comparison of proposed algorithm and traditional two Dimensional otsu algorithm is also presented. The proposed technique provides faster implementation with improved stability thereby resulting in better segmentation.

A novel approach based on GA is introduced by Pathak S. and Sejwar V. for segmentation of noisy images [37]. Comparison with some existing techniques is also presented. Various types of noise models like Salt-and-Pepper, Gaussian Noise Model, Poisson Noise and Speckle Noise were used for incorporating noise in images for testing purpose. Experiment was performed on three images which were retrieved from Gonzalez and Woods database of images. From the outcomes, it is revealed that Watershed technique is inefficient for segmentation of noise incorporated images especially when an image contains salt-and-pepper noise. Proposed technique gives promising results for segmentation of noise incorporated images.

Tan Z. and Lu R. have introduced an improved Genetic K means clustering algorithm which is then applied for segmentation [38]. Conventional GA is used with some modification of mutation operations. Outcomes of the experiments reveal that the proposed algorithm can reduce significant computing time.

A new GA based technique for detection and removal of tumor from MRI images is suggested by Halder A. et. al. [39]. Various approaches used to serve the purpose are FCM based GA, Thresholding and Morphological operations. Computer simulations of the proposed approach are also presented. Detection of Tumor from image is done with the help of segmentation and Threshold. Hence a Binary image is constructed. Tumor is then extracted from MRI images using Morphological operation. Results demonstrate that the presented approach gives promising results. Major advantage of this algorithm is that it does not require any previous knowledge for segmentation.

In the work by Yufeng G. et. al., an improved GA technique with modified crossover rate and mutation rate is applied to the two-Dimensional maximum entropy threshold segmentation approach [40]. The proposed technique is capable of solving problem of local optima, thereby improving convergence speed. Grey Correlation analysis is also applied on splitting images. The proposed image segmentation approach is efficient in terms of accuracy and speed.

Oliveira P. and Yamanaka K., have suggested a GA based image segmentation technique corresponding to a threshold method. Comparison between proposed method and otsu method is also presented [41]. The proposed technique is proved efficient and it gives promising results.

Yamamoto Y. et. al. have introduced an evolutional classification method called CBGA-LDIC for automation of knee bone segmentation in Magnetic Resonance Images (MRI) [42]. The method uses enhanced GA which extends Case based reasoning (CBGA). The objective was to produce multiple classifiers dependent on location (LDIC) and to obtain optimal combinations of classifiers by CBGA. The proposed technique is found efficient and gives encouraging results.

Li T and Guo S have proposed an improved method of 2D entropy threshold method along with modified GA [43]. Results show that the gray level distribution information is also reflected in the proposed algorithm which was not reflected in traditional techniques. The improved GA may avoid premature convergence. From results it is found that proposed approach improves threshold search speed.

Chen C has suggested a hybrid algorithm which is a combination of quantum GA and maximum fuzzy entropy [44]. In order to find optimal combination of fuzzy parameter, maximum fuzzy entropy criterion is used. Experiments reveal that the proposed approach is capable of improving speed of image segmentation.

Tiacharoen S. presented a meta heuristic algorithm for the selection of centroid for K Means segmentation [45]. GA, Particle Swarm Optimization (PSO) and Global Optimum Determination by Linking and Interchanging Kindred Evaluators (GODLIKE) are used. The results of the proposed approach is compared with that of GA, PSO and GODLIKE techniques among which proposed method gives better results.

Mylonas S. et. al. have proposed a localized version of the GeneSIS algorithm for segmentation of remote-sensing images [46]. The principle of region growing algorithms is extended by joining the broader areas connected watersheds. Proposed approach reduces significant execution time as the searching process is limited to the neighborhood of the expanding object.

Qiao Z. et. al. have suggested a support vector machine classifier based on GA for feature weighting [47]. The classifier is used for cataract detection and classification. The given image is grouped into sub-images. Feature vectors are then weighted. Fundus images are trained and classified using Support Vector Machine. Experiments show that results of proposed technique are much accurate.

Rogai F. et. al. have introduced an unseeded segmentation system that adapts itself to imitate the performance of a human expert on given dataset [48]. Simple image thresholding is used for low level segmentation. The proposed system was initially designed for ultrasound images, but it can also be applied to other image sources. The presented method gives promising results.

In the work by Pruthi J. et. al. a new Genetic Algorithm based technique using OTSU is suggested for image segmentation which solves the problems related to the conventional segmentation techniques [49]. It is revealed that the proposed approach produces better solution with respect to improved specifications like Threshold values, CPU Time and Region Non Uniformity.

Upadhyay Y. et. al. [50] introduced a Genetic Algorithm based segmentation technique for locating the size of cancer affected area of liver in an MR Image. The results of segmentation of the proposed approach have been compared with results of Watershed technique where the former technique generated optimized outcomes.

V. CONCLUSION

Image Segmentation is a vital phase in Digital Image Processing as it segregates the relevant areas of image from the irrelevant area. Segmentation decomposes an image into finite set of regions which cover the entire image. This paper reviews Image segmentation techniques. GA is an evolutionary technique which can provide unique optimal solutions for complex real world problems. It is capable of giving solutions even in a large search space. Hence GA based Image Segmentation techniques are better in comparison to existing Image Segmentation Techniques. A literature review of GA based segmentation techniques have also been reviewed.

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