Recent Trends and Techniques in Image Segmentation using Particle Swarm Optimization-a Survey

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Abstract- Particle swarm optimization is the nature inspired computational search and optimization approach which was developed on the basis of behaviour of swarm. Recently each and every field of research is utilizing the properties of PSO. One of the popular field of research is image segmentation which is also fastest growing field. Taking the advantages of combining PSO with different image segmentation technique many researchers has proposed various research papers with enhancement of various parameter. In this paper we surveyed some paper and try to provide recent trends and techniques involved in image segmentation with PSO.

Index Terms- Particle swarm optimization, Image segmentation, Thresholding, Contrast Enhancement, Fuzzy system, Clustering, Genetic Algorithm.

I. INTRODUCTION

With the continuous development of computer science and technology, research in the field of image processing gradually increased. New trend are getting turned on using Nature inspired computing in the area of image processing. One of the emerging techniques are image segmentation based on swarm intelligence.

Image segmentation is a process of partitioning an image into homogeneous regions which are more meaningful and easier to analyse. The outcome of image segmentation is an image separated in a set of regions or a set of interest extracted from the image. Pixels in each region are coordinated with respect to some specific or computed property such as color, intensity or texture.

Some of Image segmentation methods are thresholding, Edge based segmentation, Region growing, Clustering, Region splitting, and Fuzzy set image thresholding and so on. Most popular image segmentation method is Thresholding among all the existing segmentation techniques, due to its simplicity, robustness, and accuracy [2], [3]. Edge based detection is based on the discontinuity in an image. It is easily effected by the presence of noise and may lead to un-correct segmentation, Region growing overcomes the drawbacks of early image segmentation techniques. Another method is clustering which groups the data into different clusters. Fuzzy set image segmentation is the rule based segmentation and takes into account the uncertainty and fuzziness in an image

Recently, swarm intelligence (SI) is new emerging area in various fields including optimization. One of very popular SI methods is particle swarm optimization (PSO) for finding optimized solution. PSO is a stochastic search method that was developed in 1995 [1] by Kennedy and Eberhard. PSO was based on the sociological behaviour of bird flocking. It initializes a population of particles that simulates a flock of birds. The algorithm of PSO is very easy and fast to obtain solution so that it can be applied to solve a wide range of optimization problems in many fields such as image processing fields including image segmentation. The goal of this paper is to provide a state of art survey of image segmentation method based on the idea of PSO.

II. PARTICLE SWARM OPTIMIZATION (PSO)

PSO is population based stochastic optimization algorithm to find out optimized solution. Each particle in population is represented as a solution and are randomly distributed in the search space. Each particle is having its position and velocity in current population, which shows the current solution available in search space.

During flight a particle move or adjust its position to find optimum solution based on own personal best position and distance from global best particle position. At each iteration of the algorithm, particles update their current positions are weighed through fitness function.

The swarm is initialized with random particles known as candidate solution and it then searches for optima by updating its position through iterations. Two optimum values define the fitness of objective function first one is the best solution of each particle achieved so far. This value is called as “pbest” solution. Another one is the, best solution tracked by any particle among the whole population. This best value is known as “gbest’ solution.[6.2013]

$$Vi(t+1)=w\,Vi(t) + c1.r1\,(Pbest,i(t) - Xi(t)) + c2.r2\,(Gbest,i(t) - Xi(t))$$
$$Xi(t+1) = Xi(t) + Vi(t+1)$$

Where $Xi(t)$, $Vi(t)$ indicate the position the velocity of ith particle .

$Pbest,i$ indicate the personal best position of ith particle.

$Gbest,I$ indicates the global best position achieved so far.

$c1$ and $c2$ position acceleration constant $r1$ and $r2$ are random values generated between $[0, 1]$.

w is inertia weight used to provide balance between local and global search

III. LITERATURE REVIEW

Nakib *et. al.* [4] proposed a brain MRI segmentation method which was based on two-dimensional survival exponential entropy and particle swarm optimization. Introduced method

took the advantage of spatial information using the 2D-histogram. The problem of increased computational time was further solved by PSO algorithm which makes the method more suitable for real time applications with advantage of low cost.

Apurba *et. al.* [5] proposed a new approach for image enhancement based on PSO which mainly works using optimization of intensity transformation function. Intensity transformation function was fine-tuned by using local and global information of the image. Proposed method was compared with different enhancement techniques.

A new idea came to use PSO in lower-resolution multispectral images, Han *et. al.* [6] proposed a technique to solve the pan sharpening problem for remote sensing images. In proposed method the fusion parameters were optimized using the particle swam optimization (PSO) algorithm. Fusion results of the proposed approach were compared with fused images produced by some classical pan sharpening approaches.

Gao *et. al.* [7] proposed a multilevel thresholding technique which was based on the optimization based algorithm (CQPSO). This method maintains the fast convergence rate of PSO. The quantum-behaved PSO employing the cooperative method (CQPSO) was proposed to save computation time and to overcome the profanity of dimensionality. OTSU method was used to evaluate the performance of proposed method and result showed the effectiveness in terms of less computational time of the traditional OTSU method.

Zhiweid *et. al.* [8] proposed an image Segmentation technique based on 2-D Fisher and Chaos Particle Swarm Optimization Algorithm. According to the experiment, proposed method was able to improve the efficiency and accuracy of 2-D fisher method based on traditional PSO.

Milad *et. al.* [9] proposed a Image thresholding technique for segmentation of magnetic resonance images. Proposed method was combination of the multilevel thresholding algorithm and the hierarchical evolutionary algorithm (HEA) result showed that the proposed method was efficient and accurate.

Broilo *et. al.* [10] proposed an image retrieval technique Using Relevance Feedback and Particle Swarm optimization. In the paper semantic gap problem is solved through optimized iterative learning. Method was implemented in the investigation of the solution space towards the cluster of relevant images and to dynamically modify the feature space by appropriately weighting the descriptive features according to the users' perception of relevance. Results showed the efficiency and effectiveness of proposed method.

Speckle and low contrast is the main cause for degradation of image result in less detectability of targets which restricts investigation of synthetic aperture radar (SAR) images. Ying *et. al.* [11] proposed a mirror-extended Curvelet (ME-Curvelet) transform and particle swarm optimization (PSO) to solve the problem. Author had proposed a improved enhancement function which was nonlinearly shrink and stretch the Curvelet coefficients. An objective evaluation criterion was introduced to adaptively obtain the optimal parameters in the enhancement function. Experimental results showed that the proposed method can reduce the speckle and enhance the edge features and the contrast of SAR images better with comparison to the wavelet-based and curvelet-based on-adaptive enhancement methods.

Nazareth et. al. [12] proposed a new image segmentation method based on Contrast-Limited Adaptive Histogram Equalization (CLAHE) and Enhanced Convergence Particle Swarm Optimization (ECPSO). Selection of multiple thresholding is used as optimization problem and was solved by ECPSO. Experimental result showed the effectiveness of the method which outperforms Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and Bacterial Foraging (BF) Algorithms.

Qinqing *et. al*. [13] proposed image enhancement method based on improved PSO (Particle Swarm Optimization). In proposed method parameterized transformation function is used, which uses global and local information of the image which takes the advantages of the entropy of the image and edge information. The method, which was quiet simple and effective and compared with HE (Histogram Equalization), LCS (Linear Contrast Stretching) and GAIE (Genetic Algorithm based on Image Enhancement.

Apurba et. al. [14] proposed a hue preserving color image enhancement technique which was based on PSO to find optimized solution for image enhancement. In proposed method the quality of the intensity image is improved by a parameterized transformation function which was similar quiet to what Gao Qinqing [13] had proposed. In addition gamut problem is also solved by rescaling method was then compared with other techniques like hue-preserving color image enhancement without gamut problem (HPCIE) and a genetic algorithm based approach to color image enhancement (GACIE). Algorithm was very efficient and provided better results compared to other two methods.

The basic and most commonly used technique for contrast adjustment in the image is Histogram Equalization (HE), Masra *et. al.* [15] introduced a HE technique with Particle Swarm Optimization (PSO) algorithm for enhancing distorted image naturally. PSO was used for different channels (RGB) for optimization to generate best fitness value.

Enhancement of low resolution images is always a priority field of digital image processing, many algorithm and method had proposed from several years. Zhang *et. al.* [16] introduced a chaotic particle swarm optimization (CPSO) with contourlet transform for multi-scale image enhancement. In proposed method low frequency sub-bands was enhanced using contourlet transform with the help of local mean and standard deviation which enhances the overall contrast of image while high frequency band was enhanced by nonlinear gain function which enhances the local contrast of weak details. The main utilization of chaotic particle swarm optimization was to search the optimal parameters. Proposed method showed the efficiency of algorithm with different methods like histogram double equalization method, second-generation wavelet transform method. This method was good to enhance image details and suppress noise better.

Quraishi *et. al.* [17] had proposed new approach based on discrete wavelet transform (DWT) and particle swarm optimization (PSO). In addition DWT was used to decompose the input low resolution image into different sub bands. Each of the interpolated high frequency sub band (LH, HL, HH) is then summed up with the interpolated output image of the frequency domain.

PSO clustering algorithm is widely used in pattern recognition methods such as image segmentation, Raghotham *et. al*. [18] presented a new efficient algorithm which was based on PSO optimization and clustering method. Proposed algorithm was compared with KFCM and another clustering algorithm. Result showed the effectiveness of algorithm like fast convergence with good accuracy.

Shelda *et. al.* [19] proposed an image enhancement algorithm which uses the PSO as tuning the enhancement parameter of Contrast Limited Adaptive Histogram Equalization (CLAHE) which was based on Local Contrast Modification (LCM). Result was compared with other enhancement techniques such as histogram equalization, unsharpmasking and shows the effectiveness of the algorithm.

Hanmadlu *et. al.* [20] proposed a new approach which was used for enhancement of global intensification operator used in HSV color model. Author had used PSO for optimization of contrast information factor. This paper was concern of performance parameter like entropy, visual quality factor, contrast information and index of fuzziness. Evaluated result shows the improvement in quality of image, preservation of color and specific image features.

The fuzzy c-partition entropy approach was proposed by Ouarda *et. al*. [21] for threshold selection in image segmentation. In this paper complex problem of selecting threshold was solved by PSO and DE algorithms. Result showed that performance of PSO and de is equal when numbers of threshold is less but when it is more PSO outperforms DE. PSO provides better effect in terms of precision, robustness and execution time.

Pedram e*t. al.* [22] introduced a new multilevel thresholding method for segmentation of hyper spectral and multispectral images. Proposed method was based on fractional-order Darwinian particle swarm optimization (FODPSO). In contrast the concept of fractional derivative was utilized to control convergence rate of particles. Experimental results showed that FODPSO was outperform other nature inspired algorithm such as PSO and DPSO. The FODPSO presents a statistically significant improvement in terms of both CPU time and fitness value.

Ravindra *et. al.* [23] proposed a approaches to enhance contrast of image using genetic algorithm and PSO. They had used these algorithms for optimization in spatial domain and frequency domain.

Zhang *et. al.* [24] had proposed a new algorithm based on asynchronous and inertia adaptive particle swarm optimization for digital image segmentation. It was enhancement of what Quraishi [17] had proposed. In this algorithm, Adaptive threshold was gained using inertia factor into the algorithm. Obtained Result was further compared with other particle swarm optimization algorithm showed the effectiveness of algorithm in terms of stability, simplicity and easy to find optimum solution. One of the advantage of this algorithm was high segmentation speed.

TABLE 1: PSO AND OTHER HYBRID APPROACH

SN	Image processing area	PSO variant and other method	Author, year	Application, Advantages	Experiment Parameter
1	Image segmentation	Asynchronous PSO	Zhang et. al., 2015.	1. Stable 2. Easy to converge for the optimal solution 3. High segmentation speed	Swarm size :10, Maximum number of iterations : 50, Inertia weight W: 0.9 , learning factor C1=1.4324, C2=1.59612 ;
2	Thresholding (Image Segmentation)	PSO &DE Fuzzy tri-partition based PSO algorithm	Ouarda et. al., 2014.	1. Reduced time complexity 2. Execution time	swarm size :20, learning factor C1=C2=1.5, Inertia weight W=0.5;
3	Multilevel Thresholding (Image segmentation)	Support Vector Machine(SVM) and Fractional-order Darwinian PSO (FODPSO)	Pedram et. al., 2014.	1. Improved CPU time 2. Good fitness value	
5	Contrast Enhancement	PSO & Genetic Algorithm	Ravindra et. al., 2014.	1. Can be used in spatial domain and frequency domain.	
6	Image Enhancement	Contrast Limited Adaptive Histogram Equalization(CLAHE) & PSO	Shelda et. al.,2013	1. Optimum contrast enhancement. 2. Detection of breast cancer	swarm size :50, Inertia weight Wmax=2, Wmin=0.
7	Contrast	(HSV) HE & PSO	Hanmadlu et.	1. Quality of image	

	Enhancement		al. ,2013	2. Preservation of color and specific image features	
8	Image Segmentation	PSO Clustering	Raghotham et. al., 2012	1. Great Accuracy 2. Fast Convergence	
9	Infrared Image Enhancement	Contourlet transform and chaotic PSO (CPSO)	Zhang et. al., 2012	1. Performance better than double histogram Equalization	c1=c2=0.2, wmax=0.95, Wmin=0.4
10	Contrast Enhancement (Image Enhancement)	HE & PSO	Masra et. al., 2012	1. Better quality 2. Preserving the Brightness	Population 40, Maximum iterations =200, c1=c2=1, Wmax=0.8, Wmin=0.2
11	Image Enhancement	DWT & PSO	Quraishi et. al. , 2012	1. Efficient 2. Able to enhance low resolution image	
12	Image Segmentation	CLAHE & Enhanced PSO	Nazareth et. al. ,2011	1. Improved Convergence rate 2. Better than Genetic Algo. (GA) and Bacterial Foraging (BF)	
13	Image Enhancement	Simulated Annealing & PSO	Qinqing et. al., 2011	1. Improved convergence speed and accuracy	swarm size 40 leaning parameter :c 1=c2 =2,
14	Image Enhancement	PSO	Apurba et. al. , 2011	1. Removal of gamut problem	
15	Remote Sensing Image Enhancement**)**	Intensity Hue Saturation(IHS) & PSO	Han et. al., 2010	1. Outstanding spectral quality for fused images 2. Outperform HIS, GIHS	
16	Image Enhancement(Multilevel thresholding)	Co-operative Quantum Behaved PSO (CQPSO**)**	Hao et. al. , 2010	1. Less Computation time	
17	Image Segmentation	Chaos Particle Swarm Optimization (CPSO)	Zhiwei et. al. , 2010	1. Improved Efficiency and Accuracy.	Swarm size is: 10, c1=c2=2, Wmin=0.4 to Wmax=1.
18	Image Segmentation for MRI Images	Hierarchical Evolutionary Algorithm (HEA) & PSO	Milad et. al., 2010	1. Accuracy gained 96%. 2. MRI image segmentation	
19	Content-Based Image Retrieval	PSO & Relevance Feedback (RF)	Broilo et. al. ,2010	1. Better Exploration of complex, nonlinear, and High dimensional solution spaces.	c1=c2=2
20	Image Enhancement	PSO	Apurba et. al., 2009	1. Some improvements required such as fine tuning of parameters	
21	Adaptive Enhancement Method for	Mirror-Extended Curvelet Transform and PSO	Ying et. al. , 2010	1. Reduced Speckle 2. Enhanced edge features and contrast of	

	(SAR) Images			SAR images	
22	MRI Image Segmentation	2D Survival Exponential Entropy (2DSEE) and PSO	Nakib et. al. ,2007	1. Satisfactory Segmentation with a low computation cost.	

IV. CONCLUSION

In this paper we have surveyed several paper and came to conclusion that the field of PSO fastest growing field in every area. When we combined PSO with other image segmentation technique such as thresholding, fuzzy sets, histogram equalization etc performance of the method is significantly increased. In short we can say PSO is very powerful technique which can be utilized efficiently in the field of image processing.

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