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Robust Descriptive Statistics Based PSO Algorithm for Image Segmentation

Ripandeep Kaur[1], Manpreet Kaur[2]

[1, 2] Punjab Technical University, Chandigarh Engineering College, Landran, Punjab, India

Abstract: ***In this research work, we have developed a bio inspired PSO algorithm in combination with descriptive statistics equation based model. In this work, based on the mathematical relationship between the Entropy, Uniformity and the threshold measured in terms of intensity. It is found using box plot and curve fitting techniques to calculate automatic input threshold for PSO. The results show highly accurate segmentation based on this concept, as it is apparent from the values of recall and precision.***

Keywords: PSO, Robust, segmentation, descriptive statistics, Entropy, uniformity

1. Introduction

Image segmentation is a very important step in image processing and analysis. It is done by grouping the pixels in some meaningful regions to improve the presentation of the image. The main aim of image segmentation is to distinguish the object of interest from the background. Image segmentation finds applications in various areas like content based image retrieval, face detection, fingerprint recognition and in medical fields etc [1]. Number of image segmentation methods have been proposed till now such as edge detection based image segmentation, region based image segmentation, threshold based image segmentation, clustering based image segmentation and neural networks based image segmentation etc. Edge detection based method is based on finding the boundary pixels or pixels that form edges of the objects. It is useful method for the simple images such as gray scale images [2]. Region based image segmentation method operates iteratively and performs the task of image segmentation by grouping the pixels, which have some similar characteristics, in a segment and splitting the pixels in another segments which are dissimilar in value. In thresholding based image segmentation method, a threshold value is selected and image is segmented by comparing the pixel values with that threshold [3]. Clustering based image segmentation is based on an unsupervised learning method in which pixels of an image are classified into finite set of categories called clusters based on their similarity. Neural network image segmentation is used basically for medical images. The segmentation of images is done by a trained artificial neural network [4].

But, now days optimization techniques such as Ant colony optimization, Particle swarm optimization, Artificial Bee colony optimization and Genetic algorithm are also being used for image segmentation. Ant colony optimization uses the ants' capability to find the shortest path between them and their food. In the shortest path more pheromone will be deposited [5].

Particle swarm optimization is a stochastic search optimization algorithm based on the behavior of birds in a flock and results are searched using PSO in the same manner as birds in the flock search for their food. Birds learn from their own best experience and also from the experience of best bird in the flock. The same strategy is used in PSO [6]. Artificial Bee colony optimization is based on the honey bees foraging behavior. In this algorithm, the position of food source represents the solution [7].

Genetic algorithm uses biologic techniques such as mutation, inheritance etc to find the solution iteratively. In the Genetic algorithm the initial population is iteratively updated by biological operators to obtain the result [8].

2. Related Work

In the mid 1990s, social behavior among bird flocks was proposed as a new area known as Swarm Intelligence by Eberhart and Kennedy [9]. The changes to a particle within the swarm are therefore influenced by the experience, or knowledge, of its neighbors. The same behavior was used to find the optimal solution in various image processing tasks**.**

Jzau-Sheng Lin; Shou-Hung Wu[9], proposed a new PSO based algorithm using sub swarms with entropy and uniformity, but this algorithm does not consider the effect of noise and color space model of the images.

Maitra et al. [10] proposed a new thresholding algorithm for histogram-based image segmentation based on the PSO algorithm. In their algorithm, the entropy criterion has been used as a fitness function and near optimal threshold values have been searched out through maximizing the normal entropy function. As the threshold value is only dependent upon maximum entropy, this algorithm provides less robust threshold value.
Zhiwei et al. in [11] presented a new method to select image threshold automatically based on PSO. They employed the PSO technique to deal with the criteria of Otsu's for Bi-level thresholding image segmentation and Wei et al. in combined the PSO technique with Otsu's for multilevel thresholding image segmentation.

Tang Hongmei et al.[12] proposed an image segmentation method based on improved PSO algorithm. In this paper, a multilevel thresholding image segmentation method based on maximum entropy and improved PSO algorithm has been

proposed. In this work, the parameters of particle swarm optimization are improved by taking the characteristics of PSO into account. This proposed PSO algorithm results in good search stability and less computational time. Also, this proposed PSO algorithm produces better segmentation results optimal thresholds than basic PSO, which results in high computational efficiency.

3. Objective

The goal of this paper is to propose a more robust PSO algorithm with good efficiency to segment images of different sizes and formats that results in the good quality segmented images.

4. Proposed Methodology

In this paper the PSO algorithm with robust descriptive statistics of entropy and uniformity is used, in which the fitness function for image segmentation is automatically computed on the basis of relationship between entropy and uniformity. The block diagram for proposed methodology has been shown in figure 1.

In the proposed robust statistics PSO algorithm, firstly the presence of noise in the input images is checked and if it is present then removed with the help of appropriate filters. In our case best results for denoising of images were obtained by using wiener filtering. After denoising, the next step is to divide the image into Euler regions based on the connectivity of the pixels as shown in the figure 2. After dividing the image into Euler regions, the image statistics related to the minimum, maximum, mode, median and standard deviation for the entropy and uniformity of each region are found. The entropy uses the concept of Shannon's theorem and is given by the equation no.1 and uniformity is given by the equation 2.

E= -Sum (P*log2 (P)) -------- (1)

Where, E is the entropy and P denotes the histogram counts.

$$U = 1 - 2 * \frac{\sum_{j=0}^{k} \sum_{i \in Rj} (fi - mj)^2}{N * (fmax - fmin)^2} \quad \text{----- (2)}$$

Here, i is the pixel no. and fi is its gray level. mj is the average gray level and fmax and fmin are the maximum and minimum gray level of the image respectively.[9]

The descriptive statistics calculated helps to build an equation based model among variables affecting segmentation such as entropy, uniformity and threshold.

The mathematical relationship is found by plotting the sum values of 'E' and 'U' against the threshold. The threshold takes the form of polynomial equation as given in equations 3 and 4 which are computed using cube plot.
Th1 = E^E-E-3^U+(E-U)+C ---(3)
Th2 = (E^E-E)-4*E*U+(E-U)+C..(4)

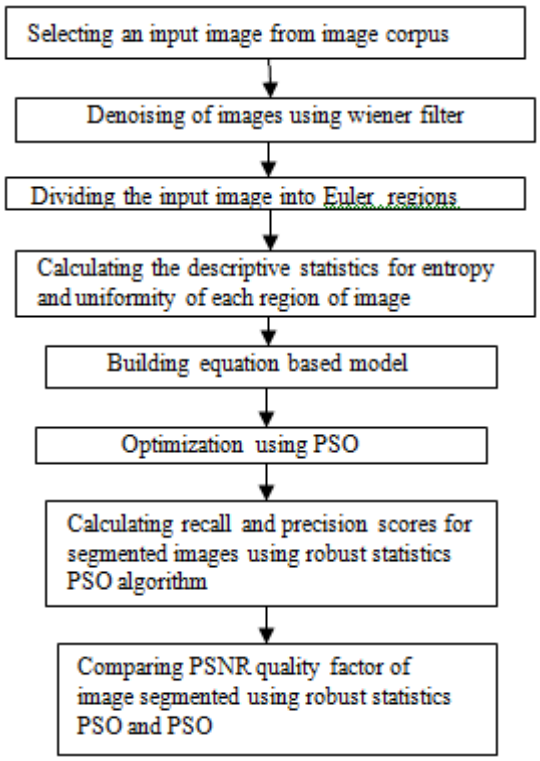

Figure 1: Flow Diagram

In the next step, the image segmentation is done by Particle Swarm optimization in which fitness function is automatically computed based on the threshold calculated using equation based model. Robust Statistics PSO algorithm is also hybrid which runs for GRAY, RGB and also HSV model of images.

Figure 2: Image divided into Euler regions

5. Results and Discussions

The implementation of robust statistics PSO has been done in MATLAB. The PSNR quality factor of this proposed robust statistical PSO algorithm has been compared with PSO algorithm. Also the recall and precision scores for segmented images are calculated.

Calculation of recall and precision scores

Precision is the ratio of the number of relevant images segmented accurately to the total number of images segmented. Mathematically,

$$\text{Precision} = \frac{\text{No. of images segmented accurately}}{\text{Total number of images segmented}}$$

$$\text{Recall} = \frac{\text{No. of images segmented accurately}}{\text{Total no. of images in the corpus}}$$

Recall is the ratio of number of relevant images that are segmented accurately to the total number of images in the image corpus or dataset. Mathematically,

The recall and precision scores calculated for the images stored in image corpus as shown in figure3 are given in the table1 and 2 respectively.

Figure 3: Image Corpus

Table 1: Recall Score

T	*A*	*B*	*C*	*Recall*	*Recall%*
Set of 10 images	7	1	2	0.175	17.5%
Set of 10 images	8	1	1	0.2	20%
Set of 10 images	9	1	0	0.225	22.5%
Set of 10 images	9	1	0	0.225	22.5%

Table 2: Precision Score

T	*A*	*B*	*C*	*Precision*	*Precision%*
Set of 10 images	7	2	1	0.7	70%
Set of 10 images	8	1	1	0.8	80%
Set of 10 images	9	1	0	0.9	90%
Set of 10 images	9	1	0	0.9	90%

Here, A denotes the correctly segmented good quality images
B denotes the correctly segmented but not displayed images
C denotes the bad quality segmented images or those images which were unable to be segmented.

T is the total number of images in a query, The graphs plotted for recall and precision scores are shown in the figure 4 and figure 5 respectively.

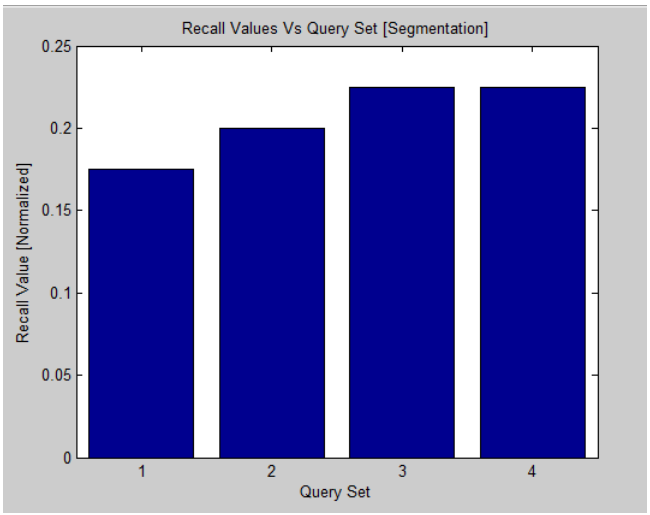

Figure 4: Recall score plot

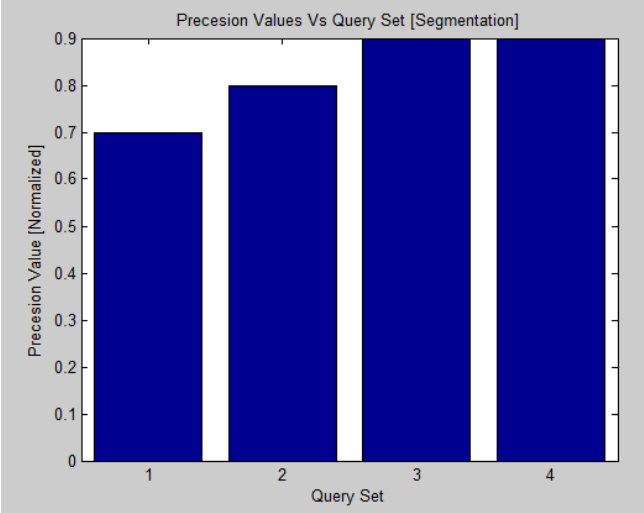

Figure 5: Precision score plot

It is clear from the above graphs that for each unique set of images, the algorithm works well as the maximum number of images from the image corpus are segmented efficiently. Also the results are maintained for all the four query sets.

Comparison of PSNR quality factors for segmented images by Robust statistics based PSO algorithm and PSO algorithm

The comparison of quality factor PSNR of segmented images has been shown in table 3. The original input images are shown in Figure 6 and Segmented images using robust statistics PSO algorithm has been shown in figure 7.

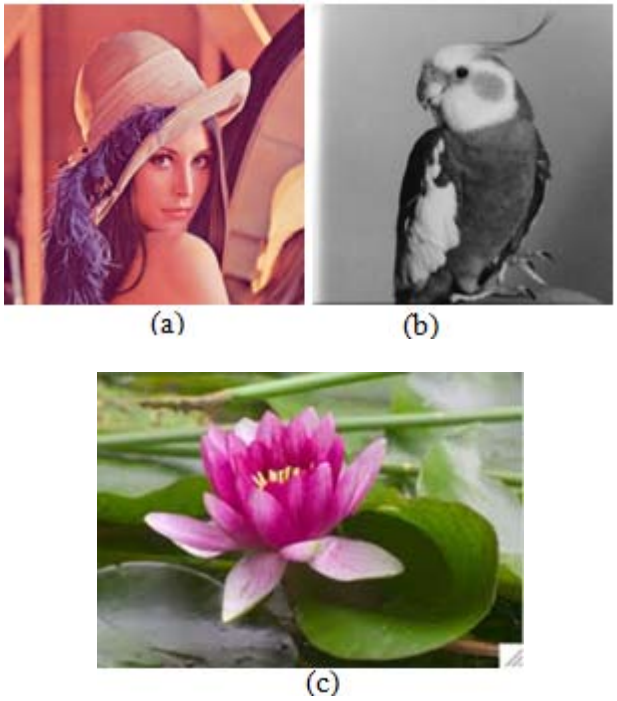

Figure 6: Original images: (a) Lena, (b) Bird, (c) Lotus

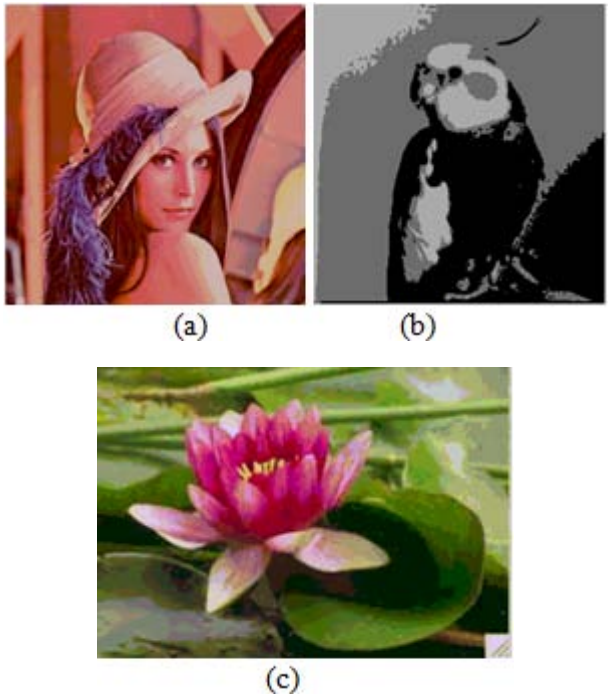

Figure 7: Segmented images: (a) Lena, (b) Bird, (c) Lotus

Table 3: comparison of PSNR for Robust statistics based algorithm and PSO algorithm

Image	*PSNR using PSO algorithm*	*PSNR using robust statistics PSO algorithm*
Lena	13.9987	24.5350
Bird	13.5660	27.1652
Lotus	15.1925	24.9385
Peppers	14.9085	27.0222
Beans	13.6670	26.2112

The graphs plotted for PSNR quality factors for the images and algorithms given in the table 3 is shown in figure 8. The green colored line indicates the PSNR values plot for proposed Robust statistics based PSO algorithm and red colored line indicates the PSNR plot for PSO algorithm for image segmentation.

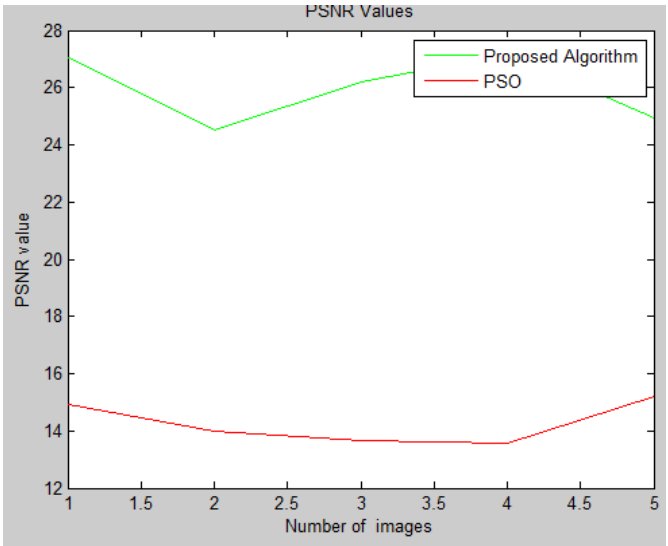

Figure 8: comparative plot of PSNR values for algorithms

From the above graph, it is apparent that the PSNR values are high in case of proposed robust statistics PSO algorithm in comparison with PSO algorithm. It means that quality of images segmented using robust statistics PSO algorithm is better than the images segmented using PSO algorithm. The percentage improvement in the proposed robust statistics based PSO algorithm from simple PSO algorithm is 82.065% in terms of PSNR factor.

6. Future Scope

For future scope, we suggest new matrices other than entropy and uniformity may be used for developing mathematical equation model for calculating threshold for image segmentation especially gray scale images. The matrices that can be used in future are cluster shade or cluster prominence and contrast as these are the most important matrices for gray scale images.

7. Conclusion

In this paper, a Robust descriptive statistics based PSO algorithm has been proposed and PSNR values for the segmented images have been compared with the simple PSO algorithm. Robust statistics PSO algorithm is based on the equation based model in which threshold is automatically computed on the basis of relation between entropy, uniformity and threshold. Robust descriptive statistics based PSO algorithm provides better results than PSO algorithm.

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Author Profile

Ripandeep Kaur received the B.tech degree in Electronics and communication engineering from Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, Punjab in 2012. Currently, She is pursuing M.tech degree in Electronics and communication from Chandigarh Engineering College, Landran, Punjab.

Manpreet Kaur received the B.tech degree in Electronics and communication engineering from GNDU, Amritsar and M.tech degree from Punjab Technical University, Jalandhar. Currently, She is working as Assistant Professor in Chandigarh Engineering College, Landran and has working experience of more than 10 years.