



Hybrid PSO Algorithm for Image Segmentation

Ripandeeep Kaur*
ECE Department&PTU,
Jalandhar, India

Manpreet Kaur
ECE Department&PTU,
Jalandhar, India

Abstract— In this research work, we have developed a hybrid PSO algorithm in combination with the relationship between the Entropy, Uniformity and threshold. Also, the recall and precision scores and MSE quality factor for the proposed Hybrid PSO algorithm have been compared with recall and precision scores and MSE quality factor for segmentation using simple PSO algorithm. The results are highly improved in case of Hybrid PSO algorithm.

Keywords— PSO, hybrid, image segmentation, equation based model

I. INTRODUCTION

Image segmentation is the process of partitioning an image into multiple regions or in the sets of pixels. It is used to locate the objects of interest. The resulting segments of the image after segmentation collectively form the input image [1]. A number of image segmentation techniques have been proposed. The type of image gives the information that which algorithm is more suitable for its segmentation. But now days, optimization techniques are widely used for image segmentation. The optimal solution obtained using these optimization algorithms should also be robust that is presence of noise does not affect its solution. Image segmentation plays a vital role in fields of medical field, image analysis and pattern recognition [2]. The use of nature inspired algorithms, such as Ant colony optimization, Artificial Bee colony optimization and PSO algorithm etc, is increasing day by day [3]. Ant colony optimization is based on the foraging behaviour of ants whereas Artificial bee colony optimization is based on the behaviour of honey bees [4,5]. PSO algorithm is based on the behaviour of birds in the flock searching their food [2]. Neural networks based segmentation is basically used in the segmentation of medical images [6].

II. PSO ALGORITHM

PSO, which is particle swarm optimization, is a stochastic bio inspired algorithm which is based on the behavior of birds in the flock. PSO was proposed by Eberhart and Kennedy in 1995[2]. It is based on the swarm intelligence and uses the same strategy which is used by birds to search their food while flying in a flock [1]. As the birds learn from their own best position and from the position of that bird which is closer to the food, the same iterative method is used in PSO to find the optimal solution. PSO algorithm has been widely used due to its simple implementation [7].

Let the swarm consists of m particles in D dimensional space. The important parameters associated with the i th particle in the Swarm at k th iteration are:

X_i = Current position of the i th particle

V_i = Current velocity of the i th particle

P_{besti} = Best position ever attained by the i th particle

G_{best} = Best position ever attained by all the particles in the flock

The velocities and positions of the particles at $k+1$ th iteration are updated according to the equations 1 and 2 respectively.

$$V_i(k+1) = W * V_i(k) + C1 * R1(P_{besti}(k) - X_i(k)) + C2 * R2(G_{best}(k) - X_i(k)) \quad \text{--- equation(1)}$$

$$X_i(k+1) = X_i(k) + V_i(k+1) \quad \text{--- equation (2)}$$

Where, $i=1, 2, \dots, m$ is the no. of particles in the swarm

W is the inertial weight, which can either be constant or decreasing function to indicate the decreasing impact of previous iteration velocity.

$C1$ and $C2$ are the cognitive and social parameters respectively which are mostly kept constant.

$R1$ and $R2$ are two randomly chosen numbers which lies in the range 0 to 1.

$P_{besti}(k) - X_i(k)$ is the cognitive component which gives idea that where is the best position of the particle

$G_{best}(k) - X_i(k)$ is the social component which gives the idea that where is the best optimal solution in that specific iteration. After some updations during iterations, the global best value nearly becomes constant and this value is the optimal solution of the problem [6].

III. PROPOSED METHODOLOGY

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

In the proposed Hybrid PSO algorithm, firstly the noise is removed from noisy images. In our case best results for denoising of images were obtained by using wiener filtering. After denoising, the image is divided into Euler regions based on the connectivity of pixels as shown in the figure 2.

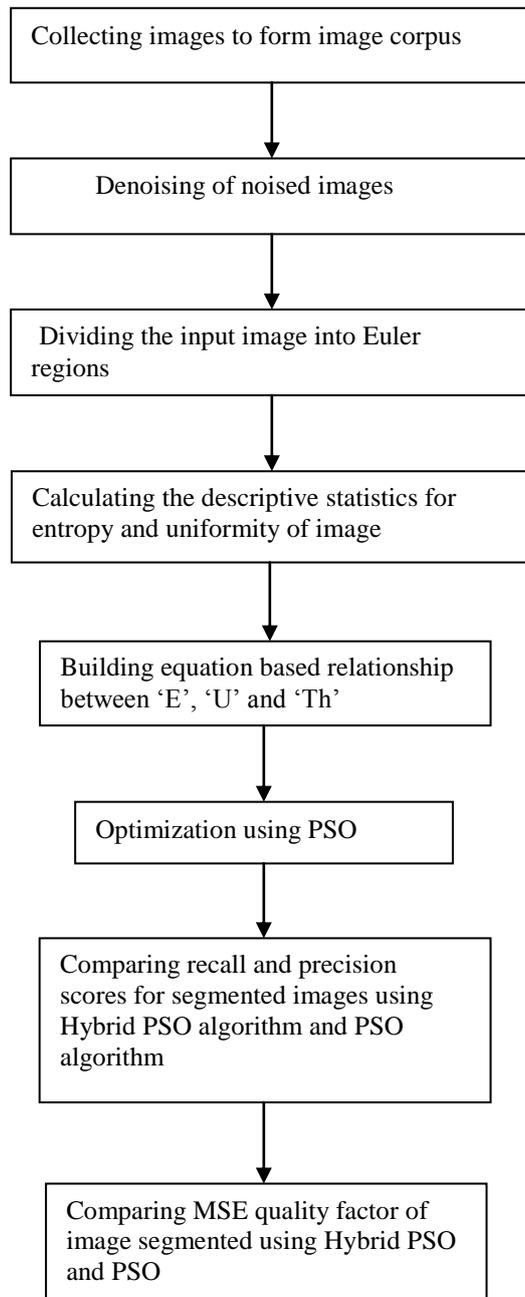


Fig. 1 Block diagram of Hybrid PSO algorithm



Fig.2 Division of image into Euler regions

After dividing the image into Euler regions, the next step is to calculate the statistics such as minimum, maximum, mode, median and standard deviation for the entropy and uniformity of each region[8]. 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.

$$E = -\sum (P \cdot \log_2(P)) \text{ ----- (1)}$$

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

$$U = 1 - 2 * \frac{\sum_{j=0}^k \sum_{i \in R_j} (f_i - m_j)^2}{N * (f_{max} - f_{min})^2} \text{ -----(2)}$$

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.[ref]

The descriptive statistics calculated helps to build an equation based relationship between 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.

$$Th1 = E^E - E - 3^U + (E - U) + C \text{ ---(3)}$$

$$Th2 = (E^E - E) - 4 * E * U + (E - U) + C \text{ ..(4)}$$

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.

IV. RESULTS AND DISCUSSIONS

The implementation of Hybrid PSO has been done in MATLAB. The MSE quality factor of this proposed Hybrid PSO algorithm has been compared with PSO algorithm. Also, the recall and precision scores for segmented images using both the algorithms have been compared.

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,

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

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,

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

The recall and precision scores calculated for the images stored in image corpus, as shown in fig.3, for Hybrid PSO algorithm and simple PSO algorithm are given in the table I and II respectively.

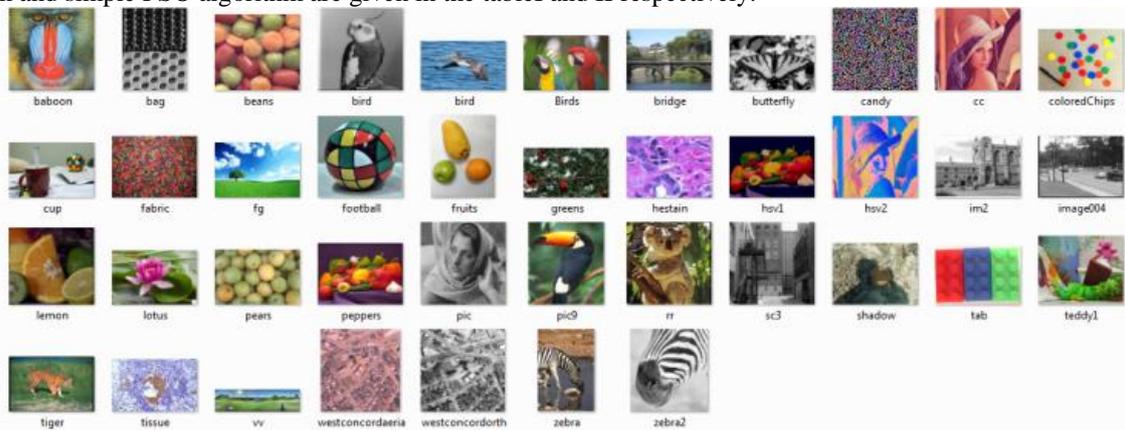


Fig.3 Image Corpus

Our image Corpus contains forty images, which are taken in four datasets containing ten images each to calculate the recall and precision scores for both the algorithms.

TABLE I: Recall And Precision Score For Hybrid PSO Algorithm

T	A	B	C	Recall Score	Precision Score
Dataset of 10 images	7	1	2	0.175	0.7
Dataset of 10 images	8	1	1	0.2	0.8
Dataset of 10 images	9	1	0	0.225	0.9
Dataset of 10 images	9	1	0	0.225	0.9

Table II: Recall and Precision Score for basic PSO algorithm

T	A	B	C	Recall Score	Precision Score
Dataset of 10 images	6	2	2	0.15	0.6
Dataset of 10 images	6	1	3	0.15	0.6
Dataset of 10 images	8	1	1	0.2	0.8
Dataset of 10 images	7	1	2	0.175	0.7

Here, A denotes the correctly segmented high quality images

B denotes the correctly segmented but fair quality 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 comparison for the two algorithms that is Hybrid PSO algorithm and simple PSO algorithm have been shown in the fig.4 and fig.5 respectively. Red colored line indicates the Precision and recall scores for the Hybrid PSO algorithm and green colored line indicates the Precision and recall scores for the PSO algorithm.

Recall Score comparison

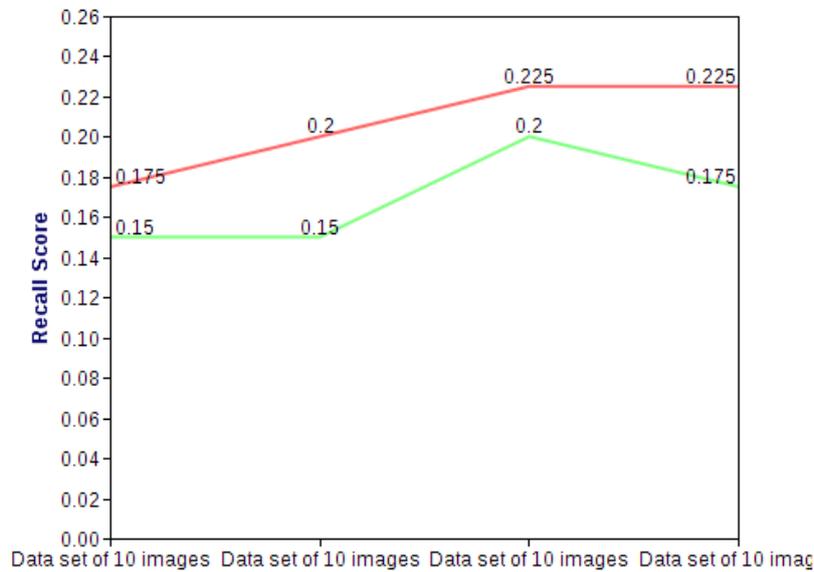


Fig.4 Recall Score Comparison

Precision Score comparison

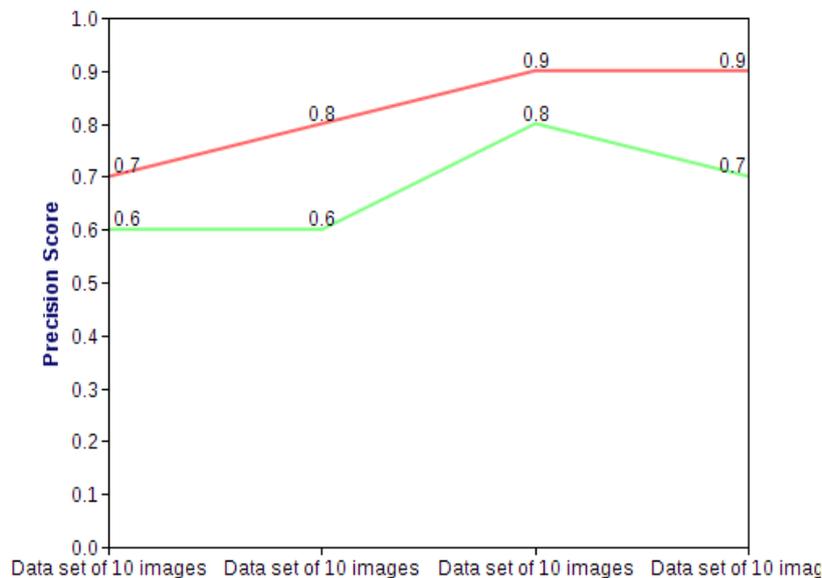


Fig.5 Precision Score Comparison

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 MSE quality factors for segmented images by Hybrid PSO algorithm and PSO algorithm

The comparison of quality factor MSE of segmented images has been shown in tableIII. The original input images are shown in Fig.6 and Segmented images using Hybrid PSO algorithm has been shown in fig.7.

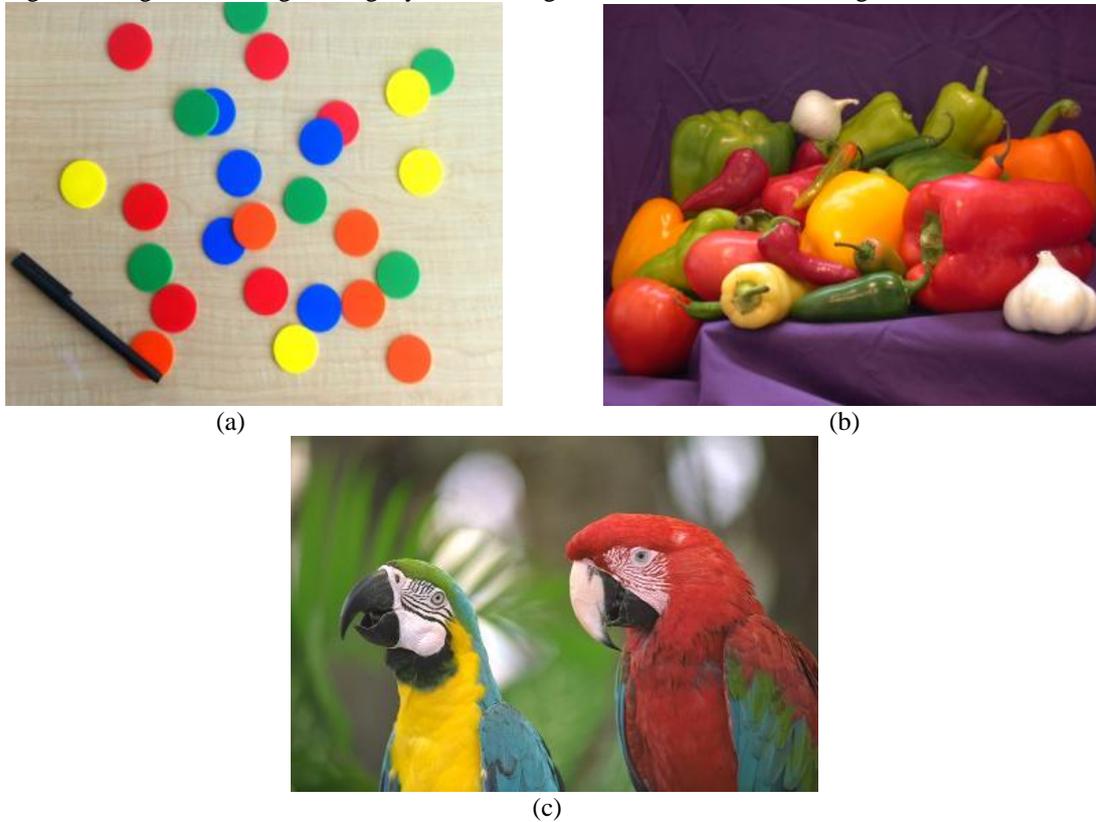


Fig.6 Original images: (a) colored chips (b) peppers (c) Birds

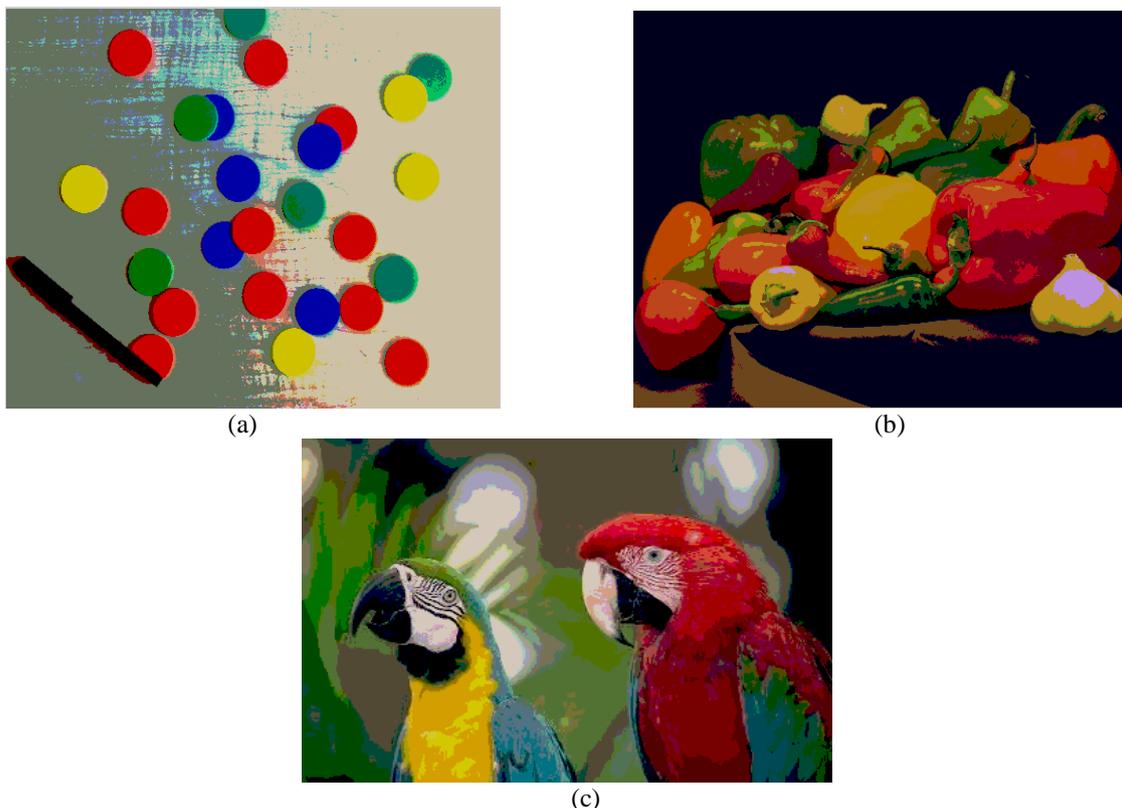


Fig.7 Segmented images: (a) Colored chips (b) Peppers (c) Birds

Table III: Comparison of MSE for Hybrid PSO algorithm and PSO algorithm

Image	MSE using PSO algorithm	MSE using Hybrid PSO algorithm
Peppers.png	224.6314	84.0700
Lena.jpg	220.8112	101.4316
Beans.jpg	211.4201	105.3202
Bird.jpg	228.3730	129.6534
Lotus.jpg	211.5346	105.5951
Barbara.jpg	221.1721	120.8807
Birds.jpg	220.9149	112.3235
Zebra.png	234.9402	95.6532
Greens.jpg	201.2865	78.1781
coloredChips.png	221.7962	93.1862

The graphs plotted for MSE quality factors for the images segmented using both algorithms given in the tableIII is shown in fig.8. The green colored line indicates the MSE values plot for proposed Hybrid PSO algorithm and red line indicates the MSE plot for PSO algorithm for image segmentation.

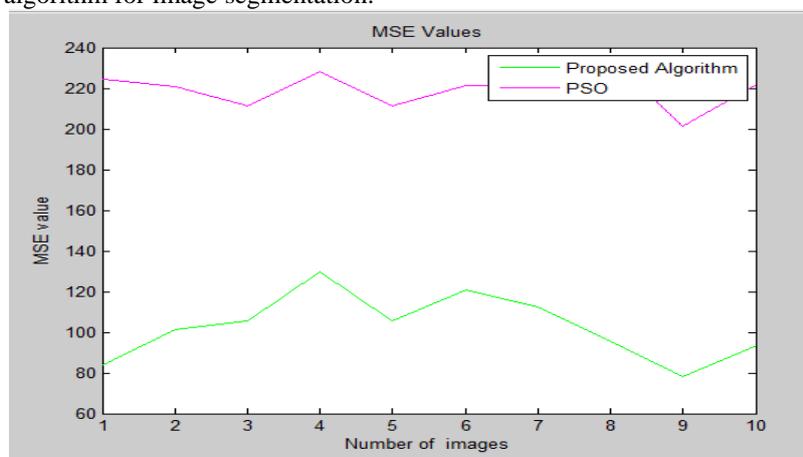


Fig.8: comparative plot of MSE values for algorithms

From the above graph, it is apparent that the MSE values are low in case of proposed Hybrid PSO algorithm in comparison with the PSO algorithm. It means that quality of images segmented using Hybrid PSO algorithm is better than the images segmented using PSO algorithm.

V. CONCLUSION

In this research paper, a Hybrid PSO algorithm has been proposed in which threshold is calculated automatically on the basis of its relationship between Entropy and uniformity. The MSE quality factor and recall precision scores of this proposed algorithm are also compared with simple PSO. It is apparent from the graphs that proposed algorithm works much better than previous PSO algorithm.

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