Image Segmentation Based on Particle Swarm Optimization Technique

Anita Tandan, Rohit Raja, Yamini Chouhan

Abstract—**Digital Image segmentation is one of the major tasks in digital image processing. It is the process of subdividing a digital image into its constituent objects. This paper gives an overview of image segmentation techniques based on Particle Swarm Optimization (PSO) based clustering techniques. PSO is one of the latest and emerging digital image segmentation techniques inspired from the nature. It was developed by Dr Kenney and Dr Eberhart in 1995, and it has been widely used as an optimization tool in areas including tele-communications , computer graphics, biological or medical science, signal processing, data mining, robotics, neural networks etc. The paper study PSO based methods to search cluster center in the arbitrary data set automatically without any input knowledge about the number of naturally occurring regions in the data, and their applications to image segmentation.**

***Index Terms*—. *Particle Swarm Optimization (PSO), PSO Clustering,* gbest, pbest,**

I. Introduction

Digital Image Processing is processing of images that are digital in nature by a digital computer. Image Processing is motivated by three major applications ;

1.improvement of pictorial info for human perception,
2.image processing for autonomous m/c application,
3.efficient storage and transmission.

The process of dividing a digital image into its multiple segments is called as Digital Image segmentation. It is one of the complex and essential tasks of image processing system. This process is performed to represent the image in a clear way. It is often used to partition an image into separate regions, which ideally correspond to different real-world objects. It is a critical step towards content analysis and image understanding. The outcome of image segmentation process is a collection of segments which combine to form the entire image. Real world image segmentation problems have multiple objectives such as minimize the features, minimize overall deviation, minimize the error rate of the classifier or maximize connectivity, etc. Particle swarm optimization (PSO) is an evolutionary computation technique developed by Kenney and Eberhart in **1995[1].** PSO is a population-based stochastic approach for solving continuous and discrete optimization problems. In particle swarm optimization, simple software agents, called particles, move in the search space of an optimization problem.

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II. Problem Statement

The objectives of this study are:

- To show that the PSO can be successfully used to solve difficult problems in pattern recognition and image processing. To develop an efficient clustering algorithm based on PSO.
- To develop a tool that can aid researchers in the unsupervised image classification field to test their algorithms, compare different clustering algorithms and generate benchmarks.
- To develop an efficient dynamic clustering algorithm that can find the "optimum" number of clusters in a data set with minimum user interference.
- To develop a PSO-based approach to tackle the color image quantization problem.
- To develop an efficient end-members selection method based on PSO for spectral unmixing of multispectral imagery data.

III. Methodology

➢ Procedure of Basic PSO

Particle swarm optimization belongs to the class of swarm intelligence techniques that are used to solve optimization problems. PSO simulates the behaviors of bird flocking. Means, a group of birds are randomly searching food in an area. There is only one piece of food in the area being searched. All the birds do not know where the food is. But they know how far the food is in each iteration. So the best way to find the food is to follow the bird which is nearest to the food. Flocking behavior is the behavior exhibited when a group of birds, called a flock, are foraging.

Each particle in PSO is updated by following two "best" values:

pbest- Each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle. This value is called personal best, pbest.

gbest- It is tracked by the PSO is the best value obtained so far by any particle in the neighborhood of that particle. This value is called Global Best, gbest.

Each particle tries to modify its position using:

- the current positions,
- the current velocities,

- the distance between the current position and pbest,
- the distance between the current position and the gbest.

After finding the two best values, the particle updates its velocity and positions with following equations

v[] = v[] + c1 * rand() * (pbest[] - ppresent[]) + c2 * rand() * (gbest[] – ppresent[]) (1)

present[] = persent[] + v[] (2)

Where;

v[] is the particle velocity, persent[] is the current particle (solution). rand() is a random number between (0; 1).c1; c2 are learning factors. usually c1 = c2 = 2.

The concept of modification of a searching point by PSO algorithm is depicted in Fig 1.

Fig 1: Concept of modification of a searching point by PSO.

- **The pseudo code of the PSO procedure is as follows:**

```
For each particle
      Initialize particle
End
Do
   For each particle
      Calculate fittness value
      If the fittness value is better than the best  fittness
      value (pBest) in history
      set current value as the new pBest
End
Choose the particle with the best fittness value of all the
particles as the gBest
For each particle
      Calculate particle velocity according equation (1)
      Update particle position according equation (2)
End
```

- ALGORITHM

Let S be the number of particles in the swarm, each having a position xi in the search-space and a velocity vi . Let pi be the best known position of particle i and let g be the best known position of the entire swarm. A basic PSO algorithm is then:

For each particle i = 1……. S do:

- Initialize the particle's position with a uniformly distributed random vector: xi ~ U(blo , bup), where blo and bup are the lower and upper boundaries of the search-space.
- Initialize the particle's best known position to its initial position: pi ← xi
- If (f (pi) < f (g)) update the swarm's best known position: g ← pi
- Initialize the particle's velocity: vi ~ U (- | bup - blo |, | bup – blo |)

Until a termination criterion is met (e.g. number of iterations performed, or a solution with adequate objective function value is found), repeat:

For each particle i = 1; :::; S do:

For each dimension d = 1; :::; n do:

Pick random numbers: rp; rg ~U(0; 1)

Update the particle's velocity:

$$v_{i,d} \leftarrow \omega v_{i,d} + \phi_p r_p(p_{i,d} - x_{i,d}) + \phi_g r_g (g_d - x_{i,d})$$

Update the particle's position: xi ← xi + vi

If (f (xi) l f (pi)) do:

Update the particle's best known position: pi xi

If (f (pi) l f (g)) update the swarm's best known position: g ← p_i

Now g holds the best found solution.

The parameters ω, ϕ_p and ϕ_g are selected by the practitioner and control the behaviour and e_cacy of the PSO method.

- Flow Chart of Algorithm

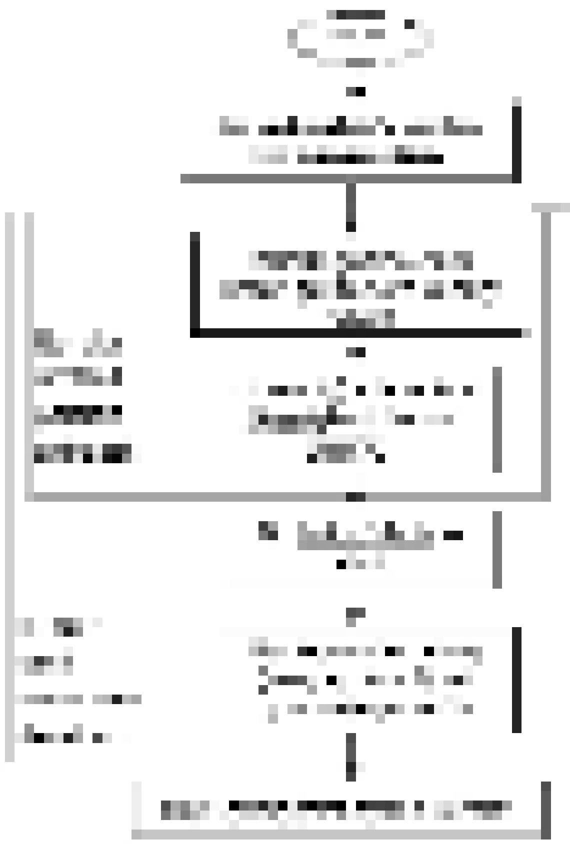

Fig 2: Flow Chart of The PSO Based Algorithm.

The application of this algorithm to the image segmentation problem can be sequenced in the following manner:

Step 1: Read the input image to be segmented.

Step 2: Select PSO method to be applied on that

image with a particular threshold level
Step 3:for each particle in the population do
update particle's fitness in the search space and
update particle's best in the search space
move particle in the population
Step 4: for each particle do
if swarm gets better then reward the swarm
spawn the particle: extend the swarm/particle life
Step5: for each particle do
if swarm is not improving its performance then punish swarm:
delete the swarm/particle: or
reduce the swarm life.
Step 6: Extend the swarm to spawn (the swarm is considered for next iteration)
Step 7: Delete the ''failed'' swarms.(the swarm will never come into search space) and
Reset threshold counter

IV. RESULT AND CONCLUSION

PSO is the natural technique of computing and provides a number of ways of solving real world problems more efficiently and quickly with accuracy. The PSO based segmented images are generally well segmented into regions of homogeneous colour and are perceptually meaningful to human's vision and can detect, automatically, very well the number of regions. The result of the algorithm discussed in this paper is shown in fig 3:

Input Image:

Output Image:by PSO

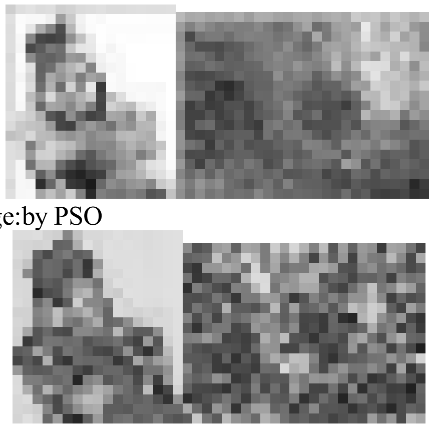

Fig 3: Result of algorithm on synthetic input images

Directions for future research are briefly summarized below:

- More specific probabilistic kernels such as Mixture Model Kernel could be and investigated to develop a mechanism that learns automatically from data the parameter of kernel function.
- Applications like computer vision, medical imaging, face recognition, digital libraries and image and video retrieval could be enhanced.
- Enhancing these PSO segmentation techniques by employing the parallel PSO algorithms and extending the techniques to the 3D cases.
- The method can be employed with Robotics and Neural Networks.

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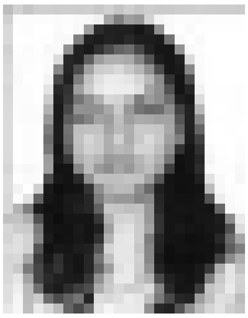
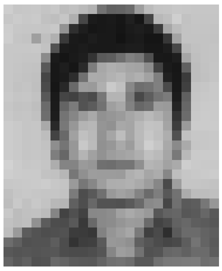
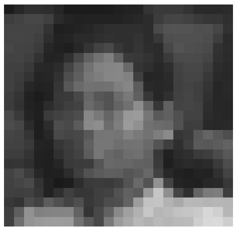
	**Ms. Anita Tandan** has completed her B.E. in Computer Science & Engineering Branch in 2008 with 1st division from Kirorimal Institute of Technology, Raigarh (Guru Gashi Das University Bilaspur). She is pursuing her M.E. in Computer Techonology and Application from Shankaracharya Group of Institution, Bhilai. At present she is in the 4th and final Semester of M.E. She had opportunities to present her R & D work in various National and International Conferences.
	**Prof. Rohit Raja** is working as a Professor in Shankaracharya Group of Institutions Bhilai(C.G.). He has received his M.E. degree in Computer Techonology and Application in 2009 from SSGI, Bhilai (C.G) and B.E. degree in Computer Science & Engineering in 2004 from R.I.T (R.S.U) Raipur (c.g). Presently he is pursuing his Ph.D. fromC.V Raman University Bilaspur.He has published more than 15 Papers in various reputed Journals, National & International Conferences.
	**Ms. Yamini chouhan** has completed her B.E. in Computer Science & Engineering Branch in 2007 with 1st division from Chouksey engineering college Bilaspur(Guru Gashi Das University Bilaspur). She is pursuing her M.E. in Computer Techonology and Application from Shankaracharya Group of Institution, Bhilai. At present she is in the 4th and final Semester of M.E.She had opportunities to present her R & D work in various National and International Conferences.