Volume : 5 | Issue : 1 | JANUARY 2016 • ISSN No 2277 - 8179

Research Paper

Particle Swarm Optimization (PSO) Based K-Means Image Segmentation Algorithm

Engineering

KEYWORDS : Swarm Intelligence, Particle Swarm Optimization, Image Segmentation, Clustering, K-Means Algorithm

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ABSTRACT

Image Segmentation plays very significant role in the fields of Digital Image Processing (DIP) for various tasks such as image understanding, image analysis, and pattern recognition etc. In current era, there is an incredible upsurge in the image data samples from every part of the world. Due to this, the necessity to introduce novel technique for an efficient segmentation has also increased.Though there are numerous traditional approaches, the efficiency of segmentation is yet to be increased. Therefore, the author proposed an intelligent based image segmentation approach in this paper. The particle swarm optimization is one of the Swarm Intelligence approach introduced in this paper as the preprocessing technique prior to the image segmentation. The image is preprocessed as to obtain the optimum pixels and then k-means clustering technique is performed on image for segmentation. The accuracy and the efficiency of the suggested methodology is matched with the prevailing k-means clustering algorithm by applying the suggested approach on different types of environmental images.

1. INTRODUCTION

Digital imaging has become the standard for all image acquisition devices. Digital Image Processing is processing of images that are digital in practical by a digital computer. DIP is inspired by three main applications like enhancement of pictographic information for human observation, image processing for sovereign machine application, effectual storing and broad casting. With lakhs of images accumulation to the image datasets, numerous images cannot be interpreted with appropriate description. In numerous real-world applications, as huge amount of images are desirable to be controlled, human relations involved in the segmentation procedure must be as minimum as probable [15]. This makes self-governed image segmentation techniques further interesting. So there is an increasing need for image segmentation and retrieval.

Image segmentation plays an energetic role in the arena of image understanding, image examination, and pattern recognition. The procedure of separating a digital image into its manifold fragments is known as Digital Image segmentation. It is one of the multifaceted and crucial jobs in image processing method. This procedure is accomplished to signify the image in a vibrant manner. It is frequently employed to segregate an image into distinct areas that preferably resemble to diverse actual entities. It is a critical stage headed for content investigation and image understanding. The consequence of image segmentation procedure is a group of segments that amalgamate to formulate the complete image. Real world image segmentation issues have manifold goals such as minimizing the attributes, minimizing complete deviation, minimizing the error rate of the classifier or maximizing the connectivity, etc.

Image segmentation is a crucial phase from image processing to image analysis, it considers a significant position. Normally, it is the origin of target expression and has significant influence on the feature dimension. Conversely, for the image segmentation, the target expression depending on segmentation, the attribute mining and constraint dimension that transforms the original image to further abstract and further compressed form, it is conceivable to make sophisticated image analysis and understanding. The Graph Based region merging algorithm attempts to partition image pixels into regions based on color information resulting into the segmentation may not be exact object information. The edge based image segmentation gives the contour(Shape) of the objects using gradient operations resulting the image segmentation as not up to the mark. The texture based segmentation using the Texture Spectrum approach gives the results for Fine Texture medical images only.

Clustering states to the methodology of combining entities such that the entities are identical within every collection. These combinations are known as clusters [16]. Clustering methodologies are employed in numerous applications, like pattern identification, image analysis, and data mining and machine learning. Clustering approaches can be categorized into two classes i.e. hierarchical and partition [17]. An extensively employed partition clustering approach is the K-means clustering approach. K-means clustering assembles the data entities into apre-specified no of groups, depending on the Euclidean distance as a similarity measure. Data samples within a group have lower Euclidean distance from each other, and are accompanied with the centroid vector that signifies the average of the data samples that pertain to the cluster. The K-means clustering has the succeeding two important benefits [17].It is flexible to execute and the time complexity is merely O(n)(where n is the no of data points), which makes it appropriate for huge data sets. None the less, its efficiency things on initial circumstances that might cause the approaches to congregate to sub optimum results. The K-means technique executes fast, however the outcome is less accurate clustering.

There are several conventional image segmentation approaches that prevail in the literature which has adopted different approaches of Clustering algorithms. The K-means clustering approach is one of the most widely used approach for an accurate and efficient image segmentation. Even though K-means algorithm is most prevalently employed, it suffers from some of the limitations in the image clustering like initialization of number of clusters, selection of initials pixel form the image etc. and easily gets trapped into the local optimum solutions.

In order to address these issues in K-means Clustering Algorithm for image segmentation, the author has introduced a novel intelligent technique into the image segmentation algorithm in this paper. This study also proposed the algorithms of combining the color, texture and shape features for segmentation. The intelligent technique that is used in this approach is Particle Swarm Optimization algorithm, which acts as a preprocessing tool for the image prior to segmentation. The preprocessing increases the efficiency of the image by obtaining the most relevant and optimized intensity image pixels which are further employed for segmentation that in turn reduced the computational complexity of the proposed Swarm Intelligence based K-Means image segmentation algorithm.

1.1 Organization of the paper

A brief introduction of image segmentation and its diverse approaches along with the k-means clustering algorithm and the motivation for the proposed methodology is given in this section. Section 2 gives the brief description of the recent issues in image segmentation using the Swarm intelligence techniques and k-means clustering algorithms. The Section 3 discusses about the Swarm Intelligence and the basic Particle Swarm Optimization algorithm. The proposed Approach is briefly explained in section 4 followed by section 5, which discussed experimental results and its wide analysis. Section 6 concludes the proposed approach and section 7 provides the references for the paper.

2. LITERATURE SURVEY

Numerous Image segmentation methods available in the literature are thresholding, edge dependent segmentation, region growing, clustering, region splitting, fuzzy set image thresholding etc. Thresholding is the meekest technique of image segmentation that splits intensity values of an image into numerous clusters. This functions competently for dual system images. Edge based recognition depends on incoherence in an image. This is effortlessly stimulated through the existence of noise and might tend to complete in addition to segmentation. The Region growing approach over whelms disadvantages of primary image segmentation procedures. The other methodology is clustering that assembles information to a diverse groups. Fuzzy set image segmentation is the rule dependent segregation and considers the ambiguity and fuzziness in an image. The numerous applications of image segmentation are finding lumps [25], face identification [26],[27] and image recovery [28] etc.

Currently particle swarm optimization (PSO) [18,19] has been performed on image clustering [20] and it has been presented in [20] that PSO-dependent image clustering has improved performance compared to K-means. Yin et. al. [1] suggested a methodology that employs PSO in combine with lowest cross entropy to attain a threshold for image segmentation. This technique over whelms the issue of time taking. Outcomes of this approach is matched with exhaustic exploration techniques. Nakib et. al. [2] presented two-dimensional subsistence exponential entropy using PSO for segregation of magnetic resonance imaging (MRI) images. Primarily, the two dimensional histogram is acquired so as to evade the issue of altitudinal circulation. This method regulates the amounts of thresholds optimum.

Primarily two thresholding procedures are enhanced by means of the techniques explicitly, they are Kapur'stechnique [3] and Otsu'stechnique [4]. The consistency measure is employed to estimate the eminence of threshold images. Execution outcomes are demonstrated where the calculation period of Otsu's technique is superior to Kapur'stechnique. Consequently the methodology that employed Otsu'stechnique is additionally competent. The conventional FCM clustering approach is delicate to noise. One of the modes approach is low pass filtering of an image and formerly performing the FCM clustering approach. Disadvantage of this technique was that it might tend to damage the significant information existing in the image. As to overwhelm this limitation, a significant FCM clustering approach is given by Shen et. al. [5]. A vital constraint that could disturbs ability of FCM clustering approach is the constraint optimization.

Forouzan feret. al. [6] presented a breeding swarm intelligence approach which assists to discover optimal attraction constraints. The upbringing swarm approach gathers power of PSO and genetic algorithm together. Koleet. al. [7] defined a methodology for image segmentation by means of hybrid procedure depending on PSO and GA. PSO grounded dynamic clustering is employed to discover optimum no of groups. This data is additionally employed through genetic algorithm to progress ultimate outcome of the PSO dependent approach. Finally, the finest outcome is attained by matching their personal validity indices [8] and the information is segregated consequently.

Omran et. al. [9] suggested a vibrant clustering depending on PSO. Primarily, this approach separates the information into the comparatively huge no of groups so as to diminish consequence of primary situations. The binary PSO aids to choose the finest no of groups. Eventually, centers of preferred clusters are enriched via k-means clustering. One of the benefit of this approach is that consumer could prefer any rational index pertaining to specified information. Chun et. al. [10] presented a methodology that employed FCM clustering combined with PSO. The foremost aim of FCM clustering is to discover cluster centers which increased the similarity function or diminishes the dissimilarity function.PSO is employed to allocate every intensity value to a cluster. This hybridized FCM clustering and PSO methodology generates improved segmentation outcomes.

Jing et. al. [11] suggested a fast FCM methodology in combined with PSO for image segmentation. PSO approach is an optimization procedure that spontaneously specifies the no of clusters along with the center of the clusters. The sonar images has small signal to noise proportion. Consequently, it gets challenging to segements images. Liu et. al. [12] suggested a PSO dependent fuzzy cluster for sonar image segmentation. The amalgamation inclines to generate robust exploring and maximum speed convergence capability. Furthermore, the fuzzy measure and fuzzy integral are likewise estimated to evaluate the fitness.

Jing et. al. [13] suggested a technique to appropriately clusters that are similar to each other. The t-Particle Swarm Optimization (t-PSO) is employed to resolve composite calculation in addition to early constraint understanding issues so as to obtain accurate segmentation. So as to eliminate the healthiness of FCM to noise, Liu et. al.[14] suggested novel hybrid procedure employing fuzzy PSO and markov arbitrary area. The spatial data defined by markov arbitrary domain system is employed to alter the similarity measure of FCM. The segmentation is performed equivalent to the global finest location, meanwhile it is fewer time taking and likewise accelerate the speed of the procedure when matched to the local best location.

3. PARTICLE SWARM OPTIMIZATION

Swarm intelligence is a simulated intelligence prototype that is principally motivated from numerous societies in the environment, for example ant-colonies, bird-flocks,fish-schools, etc. SI is dependent on the communal, cooperative and arranged behavior of dispersed, self-organized agents [24].Particle swarm optimization (PSO) is an evolutionary computation procedure established by Kenney and Eberhart in 1995[18]. PSO is a population-dependent stochastic technique for resolving un interrupted and distinct optimization issues. In particle swarm optimization, modest software agents, known as particles, travel in the search domain of an optimization issue. PSO is the usual procedure of computing and offers numerous approaches to solve real life issues further professionally and rapidly with accuracy. The PSO grounded segmented images are normally well segmented into areas of identical color and are perceptually significant to human's visualization and can identify, spontaneously, very well the number of areas.

PSO concept is grounded on representation of surrounding communication like bird flocking and fish schooling. Particle Swarm Optimization (PSO) depends on communal behavior of group of particles: the particle swarm. In meekest and unique form of PSO, every individual of particle swarm is stimulated by a problem domain using two flexible services. One fascinates through arbitrary magnitude to its finest position until now met by the particle. Another fascinates through arbitrary magnitude to its finest position met by any individual of the swarm [21, 22, 23]. PSO comprises of a group of individual and every individual wings over the multi-dimensional exploration domain through the velocity that is continually updated by the particle's preceding finest performance and by the preceding finest performance of the particles adjacent. PSO could be effort lessly executed and is computationally cheap incase of memory necessities and CPU speed together.

The position and velocity of every particle are updated at every time step unless the group all together congregates to an optimal. Particles update its velocity and position by means of outlining two types of 'best' value. One is its personal best (pbest) that is the position of its upper most fitness value. In global form, the other is the global best (gbest) that is the position of complete best value, attained by any particles in the populace.

Procedure for Basic PSO
Particle swarm optimization pertains to the group of swarm intelligence approaches that are employed to resolve optimization issues. Every particle in PSO is updated by succeeding two "best" values:

Pbest: Every particle retains the way of its coordinates in the result domain that are accompanied with the best result (fitness) that has attained up to now by that particle. This value is known as personal best, pbest.

Gbest: It is traced by the PSO which is the finest value attained until now by any particle in the neighborhood of that particle. This value is known as Global Best, gbest.

The comprehensive procedure of particle swarm optimization [11] is specified underneath:

1. Initialization:The velocity and position of entire individuals are arbitrarily set to within pre-specified ranges.
2. Velocity Updating: In every generation, the velocities of entire individuals are updated rendering to:

)+)

Here and are the velocity and position ofparticle I, correspondingly. and are theposition with the 'best' objective value establish until now by particle *i* and the complete populace correspondingly; *w* is employed to regulate the convergence behavior of PSO; and are arbitrary variables in the range [0, 1]; andregulator how distant an individual travel in onegeneration. Afterwards updating, velocity must be tested and protected within a predefined range to evade forceful arbitrary walking.

3. Position Updating: Presuming a unit time intermission amongst consecutive generations, the locations of entire individuals are updated rendering to:

=

Later updating, must be tested and restricted to the permissible range.

4. Memory Updating: Update and whenever circumstance are encountered then,
5. Termination Checking: The algorithm replicates Steps2 to 4 until certain stopping criterion are attained, for example a pre-specified no of generation or a failure to make improvement for a certain no of generation. Once concluded, procedure specifies the values of and as its result.

4. PROPOSED METHODOLOGY

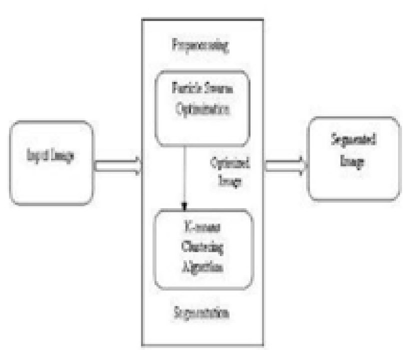
Numerous optimization approaches, in specific clustering methods, have been motivated by such environmental occurrences as neural systems and networks, casual evolution of the resistant system, and currently swarms and colonies. The K-means algorithm is one of the extensively employed clustering approach in the image clustering models. In this paper, a novel methodology is presented depending on the notion of Swarm Intelligence and K-Means Clustering Algorithm. This novel approach is known as Particle Swarm Optimization based K-means Image Segmentation. The complete approach is explained in two stages:

1. Preprocessing of the raw image
2. Applying segmentation algorithm on the optimized image

The preprocessing of the raw image is done by means of particle swarm optimization technique where the pixels having optimizes intensity values remains unchanged and the other pixels are altered depending on the fitness function. The fitness evaluation function that is employed in this approach is the mean square of Euclidean distance measure. The PSO algorithm is implemented with 100 number of generation and the termination criterion for the approach is maximum generations. The preprocessed or the obtained optimized image is given to clustering algorithm for segmentation. The number of cluster for segmentation depends on the user's choice. The traditional K-means Partitioning algorithm is employed to obtain an efficient segmented image with high resolution of the color and texture. These PSO heuristics makes the K-means algorithm more constant for discovering improved results and few erreliant on the preliminary cluster centers. The block diagram of the proposed approach is given in Fig.1.

4.1 Particle Swarm Based K-means Image Segmentation Algorithm

- Consider a raw image I of size MXN for the segmentation.
- Initially the color space of this resolution image is converted from RGB color space to Grey Level Image.
- Perform Particle Swarm Optimization algorithm on these raw images by initially selecting N number of pixels from the image.
- Assign random position and velocity values on these initialized N number of Pixels and estimate fitness for each pixel.
- Update the Pbest and Gbest of the pixel by means of the equation 1 and 2 given above.
- Repeat steps 1 to 3 until the termination criterion is attained that is maximum number of generation.
- Then the optimized preprocessed image is obtained from the step 1 to 3, which in turn is given to the K-means Clustering Algorithm.
- Select M/2 number of initial cluster for segmentation and initialize the pixels values for each cluster randomly.
- Find the Euclidean distance between the pixel values and update the centroids (pixels) of the clusters.
- Repeat the steps 1 to 2 until the convergence for the approach is attained and finally with the specified number of clusters obtained the segmented image.
- The segmented grey image is again converted back to the RGB color space.



Volume : 5 | Issue : 1 | JANUARY 2016 • ISSN No 2277 - 8179

Fig 1: Block Diagram for the proposed Approach

5 .EXPERIMENTAL RESULTS AND ITS ANALYSIS

The Experimental Analysis of the proposed Particle Swarm Optimization (PSO) based K-Means Image Segmentation Algorithm is evaluated with the help of the environmental images in this proposed paper. The performance evaluation of the proposed methodology is compared with existing K- means image segmentation algorithm. The proposed image segmentation uses particle swarm optimization to identify featured color values from an image. The extracted feature color values are then feed to k-means clustering algorithm to identify number of clusters and the clusters were generated. The generated clusters are extracted from the base image and displayed. The number of clusters was considered as the number of different colors in the image.

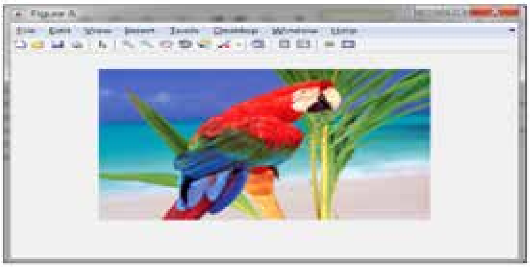


Fig 2: Test Image

Fig 3: Image Labeled by Clustered Index

Fig. 3 represents the image labeled by the clustered index. This image was segmented by means of the K-means procedure with mean and variance as features with numbers of clusters (NC) are 8 which institutes the initial populace for the PSO. These are the images clustered by different indexes. Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, Fig. 10, Fig. 11 represents eight clusters for the image. The interface for the experimented result is given in Fig. 12.

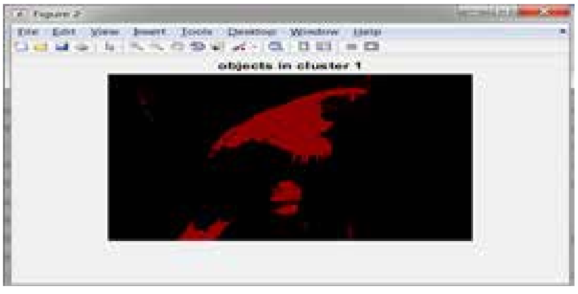


Fig 4: Image of Cluster 1

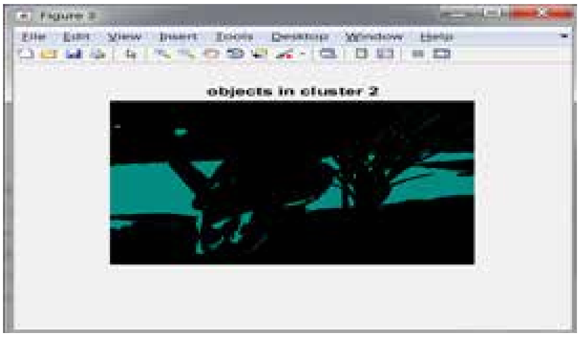


Fig 5: Image of Cluster 2

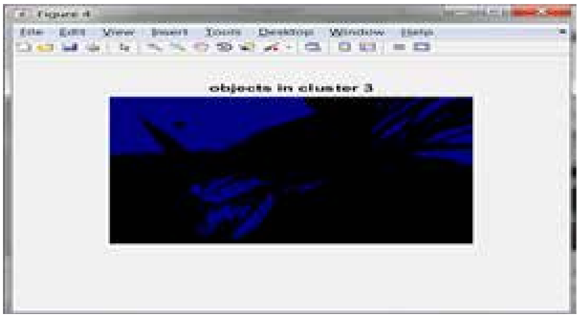


Fig 6: Image of Cluster 3

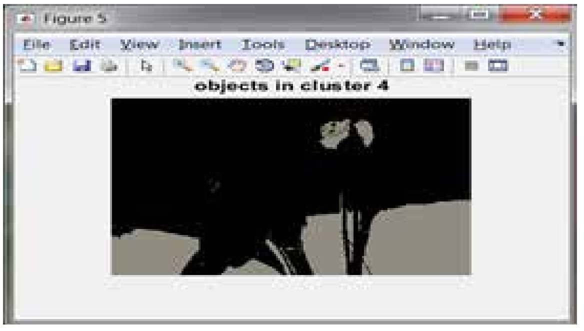


Fig 7: Image of Cluster 4

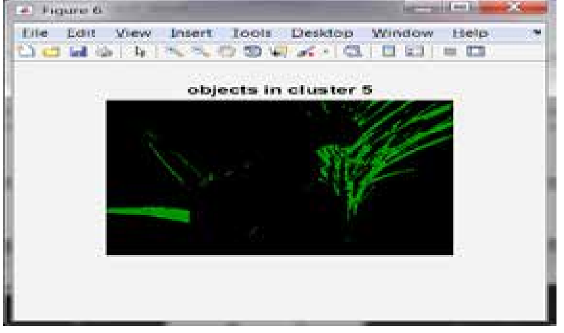


Fig 8: Image of Cluster 5

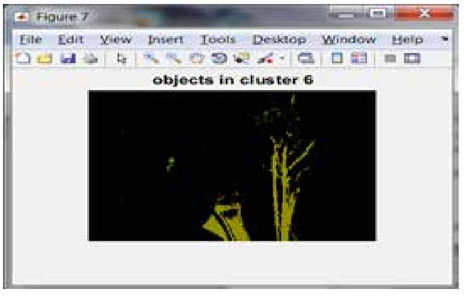
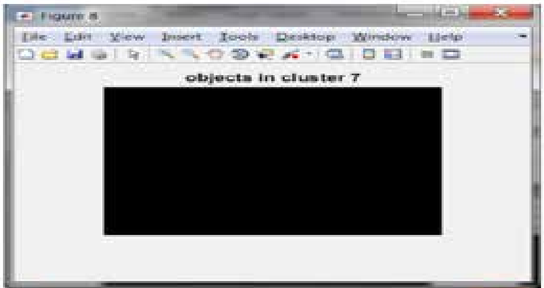


Fig 9: Image of Cluster 6



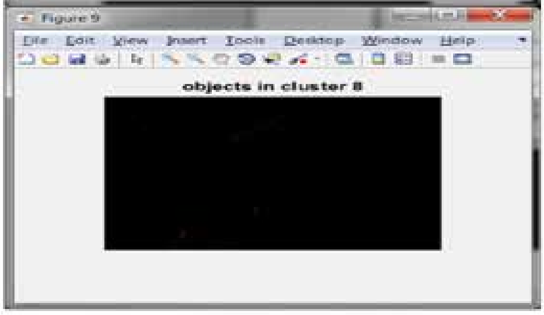


Fig 10: Image for Cluster 7
Fig 11: Image for Cluster 8

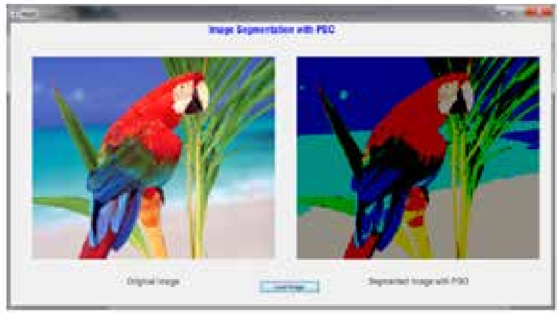


Fig 12: Interface to load an Image

6. CONCLUSIONS

In this paper, a novel segmentation technique is proposed depending on Swarm intelligence and k-means clustering algorithm as to improve efficiency and accuracy of the segmented image. The Swarm Intelligence that is Particle Swarm Optimization Algorithm is presented as preprocessing technique to obtain the optimal image from the raw data. The K-means clustering algorithm acts as the segmentation technique. The PSO heuristics makes the K-means algorithm further constant for obtaining improved results and few erreliant on the initial cluster centers. Variations in the performance of the proposed algorithm and the existing system are tested using the experimental results and its analysis.

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