A Review on Image Segmentation using Clustering and Swarm Optimization Techniques

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Abstract— The process of dividing an image into multiple regions (set of pixels) is known as Image segmentation. It will make an image easy and smooth to evaluate. Image segmentation objective is to generate image more simple and meaningful. In this paper present a survey on image segmentation general segmentation techniques, clustering algorithms and optimization methods. Also a study of different research also been presented. The latest research in each of image segmentation methods is presented in this study. This paper presents the recent research in biologically inspired swarm optimization techniques, including ant colony optimization algorithm, particle swarm optimization algorithm, artificial bee colony algorithm and their hybridizations, which are applied in several fields.

Key words: ACO, PSO, Image segmentation, K-Mean Fuzzy C-Means

I. INTRODUCTION

The principle of image segmentation is to division an image into particular regions with respect to a suitable application. Essential step is used for image analysis in Image segmentations are object visualization, object representation and several other image processing jobs. In image segmentation, segmentation is stand on measurements in use from the image and might be grey level, color, texture, motion or depth. At first, Segmentation partitions an image into its essential objects or regions. Segmentation permits in extracting the objects in images. In image processing segmentation of images is not an easy job. Segmentation is an unsupervised learning. Model based object extraction is a supervised learning, e.g., template matching. After a successful segmenting the image, the contours of objects can be extracted using edge detection and/or border following techniques. Shapes of objects are based on texture, shape and color objects can be recognized. Image segmentation methods are broadly used in comparison searches.

Segmentation algorithms are supports on one of two essential properties of color, texture or gray values: similarity and discontinuity. First category is based on partitioning an image into regions that are similar, according to predefined criteria. Histogram thresholding approach falls under this category. Second category is to partition an image based on abrupt changes in intensity, such as edges in an image.

Generally image segmentation is a primary and vital step in a sequence of processes aimed at overall image understanding. Applications of image segmentation contain:

- Identifying objects in a picture for object-based measurement like as shape and size.
- Identifying objects which are at dissimilar distances from a sensor using depth dimensions from a laser range finder enabling path planning for mobile robots.
- In object-based video compression (MPEG4) objects identifying in a moving scene.

Since a technique applied to single image may not remain doing well to other type of images, therefore segmentation methods have been separated into three categories, i.e. segmentation techniques support on classical method, hybrid techniques and AI techniques. A number of the most well-known image segmentation methodologies including Edge based segmentation, Fuzzy theory based segmentation, Partial Differential Equation (PDE) based segmentation, Artificial Neural Network (ANN) bases segmentation, threshold based image segmentation, Region based image segmentation and threshold based image segmentation are highlighted in figure. Fig.1 enclosed main and well-known image segmentation techniques used for the purpose of image segmentation.

II. IMAGE SEGMENTATION TECHNIQUES

Various image segmentation techniques have been expanded by researchers and scientists, some of the most important and commonly used image segmentation techniques are shown in Fig.1. Latest research work on image segmentation techniques highlighted in Fig.1 is discussed and evaluated below.

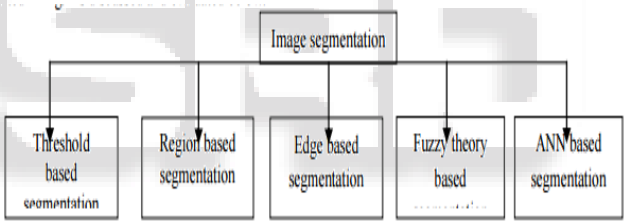

Fig. 1: Techniques of Image Segmentation

A. Threshold Based Image Segmentation

Thresholding is an old, simple and popular technique for image segmentation. By thresholding Image segmentation is easy but controlling approach for segmenting images having light objects on dark background. By the Thresholding operation a multilevel image convert into a binary image i.e., it select a proper threshold T, to split image pixels into separate objects and several regions from background.

Some pixel (x, y) is measured as a part of object if its intensity is greater than or equal to threshold value i.e., $f(x, y) \geq T$, else pixel belong to background. There are two types of thresholding methods. They are classified as local and global thresholding. If T is constant then it is known as global thresholding otherwise it is local thresholding.

Global thresholding techniques can fail when the background illumination is uneven. In neighboring thresholding, multiple thresholds are used to compensate for uneven illumination. There are some disadvantages of thresholding method. It generates only two classes, and it cannot be used to multichannel images. Thresholding does not take into account the spatial characteristics of an image so it is sensitive to noise. This corrupts the histogram of the image, making separation more difficult[1].

B. Region Based Image Segmentation

This segmentation is easy as judge against to other methods and also noise resilient. It partitions a picture into distinctive areas taking into account pre-characterized criteria, i.e., color, intensity, or object. Region based segmentation technique are ordered into three principle classifications, i.e., region growing, region splitting, and region merging [2].

C. Edge Based Image Segmentation

It is essential step for image segmentation process [3]. It isolates an image into objects and its background. Edge recognition separates the image by watching the adjustment in power or pixels of a image. Gray histogram and Gradient are two fundamental routines for edge detection for image segmentations [4]. A few administrators are utilized by edge detection technique, i.e., Classical edge locators, zero crossing, Laplacian of Guassian (LoG)[5], and color edge detectors. [6].

D. Fuzzy Theory Based Image Segmentation

This technique is used in arrange to analyze images, and give correct in order from any image. Fuzzification function can be utilized to expel noise from images too [7]. A gray scale image can be effortlessly changed into a fuzzy image by utilizing a fuzzification function. Diverse morphological operations can be joined with fuzzy method to show signs of improvement results [8]. Fuzzy k-Means and Fuzzy C-means (FCM) are generally utilized techniques as a part of image processing [9].

E. ANN Based Image Segmentation

In Artificial Neural Network, each neuron is equivalent to the pixel of an image. Image is mapped to the neural network. Image as neural network is prepared utilizing preparing tests, and after that association between neurons, i.e., pixels are found. At that point the new images are segmented from the prepared image [10]. A portion of the generally utilized neural network for images division are Hopfield, BPNN, FFNN, MLFF, MLP, SOM, and PCNN. Segmentation of images utilizing neural network is execute as a part of two stages, i.e., pixel classification and edge detection [11].

III. Clustering Algorithms

Clustering algorithms can be divided into three categories as follows [12]

- Partitioning Clustering
- Hierarchical Clustering
- Density-based Clustering

Partitioning algorithms attempt to determine k clusters that optimize a certain, often distance-based criterion function. Hierarchical algorithms create a hierarchical decomposition of the database that can be presented as a dendrogram. Density-based algorithms search for dense regions in the data space that are separated from one another by low density noise regions.

A. Partitioning Clustering

Partitioning clustering partitions an arrangement of N items into k clusters such that the segments streamline a sure rule function. Every cluster is indicated to by the centroid of the group, or by medoid, for instance k-medoids. Normally, k seeds are arbitrarily chosen and afterward a relocation scheme iteratively reassigns focuses between groups to upgrade the clustering paradigm. The minimization of the square-error basis - whole of squared Euclidean distances of focuses from their nearest cluster centroid, is the most usually utilized. A genuine downside of partitioning algorithms is that there are various conceivable solutions.

B. K- Means

K-means is perhaps the most popular clustering method in metric spaces. Initially k cluster centroids[13,12] are selected at random; k-means then reassigns all the points to their nearest centroids and recomputed centroids of the newly assembled groups. The iterative relocation continues until the criterion function, e.g. square-error converges. Despite its wide popularity, k-means is very sensitive to noise and outliers since a small number of such data can substantially influence the centroids. Other weaknesses are sensitivity to initialization, entrapments into local optima, poor cluster descriptors, inability to deal with clusters of arbitrary shape, size and density, reliance on user to specify the number of clusters. Finally, this algorithm aims at minimizing an objective function; in this case a squared error function.

$$\arg\min_c \sum_{i=1}^{k} \sum_{x \in c_i} d(X, \mu_i) = \arg, min_c \sum_{i=1}^{k} \sum_{x \in c_i} \|x - \mu_i\|_2^2$$

where || xi(j) – cj ||2 is a chosen distance measure between a data point xi(j)and the cluster centre Cj, is an indicator of the distance of the n data points from their respective cluster centres.

C. Fuzzy C- Means

In this algorithm, each point has a level of having a place with groups, as in fuzzy algorithm, as opposed to having a place altogether too simply single group. Consequently, focuses on the edge of a group can be in the bunch to a littler degree than focuses in the focal point of group. For every point x we have a coefficient giving the level of being in the kth bunch uk(x). More often than not, the total of those coefficients is characterized to be

$$\forall x \quad \sum_{k=1}^{num.clusters} u_k(x) = 1\_$$

With fuzzy k-means, the centroid of a cluster is the mean of all points, weighted by their degree of belonging to the cluster**:**

$$\text{center}_k = \frac{\sum x \, uk(x) m_x}{\sum x \, uk(x) m} \_$$

The degree of fit in is related to the inverse of the distance to the cluster center:

$$u_k(x) = \frac{1}{d(\text{center}_k, x)^x}$$

then, the coefficients are normalized and fuzzy fired with a real parameter m > 1 so that their sum is 1.
So

$$u_k(x) = \frac{1}{\sum j \left(\frac{d(\text{center}_k, x)}{d(\text{center}_j, x)}\right)^{2/(m-1)}}.$$

For m equivalent to 2, this is equal to normalizing the coefficient straightly to make their whole 1. At the point when m is near 1, then group focus nearest to the fact of the matter is given substantially more weight than the others, and the calculation is like k-means. The fuzzy k-means calculation is fundamentally the same to the kmeans calculation:

1) Choose various bunches.
2) Assign randomly to every point coefficients for being in the bunches.
3) Repeat until the calculation has united (that is, the coefficients' change between two cycles is close to ε, the given affect ability threshold)

D. Hierarchical Algorithms

Unlike partitioning methods that create a single partition, hierarchical algorithms[5] produce a nested sequence (or dendrogram) of clusters, with a single all-inclusive cluster at the top and singleton clusters of individual points at the bottom. The hierarchy can be formed in top-down (divisive) or bottom-up (agglomerative) fashion and need not necessarily be extended to the extremes. The merging or splitting stops once the desired number of clusters has been formed. Typically, each iteration involves merging or splitting a pair of clusters based on a certain criterion, often measuring the proximity between clusters**.**

E. Density-Based Clustering Algorithms

Density-based clustering methods assembly nearing objects into clusters based on neighboring density conditions rather than proximity connecting objects. These techniques see clusters as thick regions being isolated by low density uproarious regions. Density based methods have commotion resilience, and can find non-curved clusters. Like various leveled and apportioning strategies, density based methods experience troubles in high dimensional spaces on account of the inalienable shortage of the element space, which thusly, diminishes any clustering tendency.

IV. VARIOUS OPTIMIZATION TECHNIQUES

Optimization is a usually encountered numerical problem in all engineering disciplines. It actually means discovering the best possible/desirable solution. Optimization problems are far reaching and various, thus systems for taking care of these issues should be a dynamic research topic. Optimization algorithms can be either deterministic or stochastic in nature. Previous techniques to take care of enhancement issues require tremendous computational efforts, which have a tendency to come up short as the issue size increments. This is the motivation for employing bio inspired stochastic optimization algorithms as computationally efficient alternatives to deterministic approach [14].

A. Evolutionary algorithms

EA's are most known, established algorithms among all other Optimization algorithm. EA's use the methods used by all living organisms to interact with each other. These algorithms used this powerful strategy to find solution to hard problems. EAs are non-deterministic algorithms or cost based algorithms.

B. Swarm Intelligence based algorithm

This is based on collective behavior of organisms. SI works on the implementation of groups of simple agents that are based on the behavior of real world insect swarms, as a problem solving tool.

1) Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) is a computational insight arranged, stochastic, population based global optimization technique proposed by Kennedy and Eberhart in 1995[15]. It is motivated by the social activities of bird flocking searching for food. PSO has been broadly connected to numerous engineering optimization areas because of its one of a kind searching method, straightforward idea, computational proficiency, and simple implementation.. In PSO, the term ―particlesε alludes to population members which are mass-less and volume-less (or with a discretionarily little mass or volume) and are liable to speeds and increasing speeds towards a superior method of conduct. Every particle in the swarm speaks to an answer in a high-dimensional space with four vectors, its current position, best position discovered in this way, the best position found by its neighborhood so far and its velocity and modifies its position in the hunt space in view of the best position came to without anyone else's input (pbest) and on the best position came to by its neighborhood (gbest) during the process. In every iteration, each particle updates its position and velocity.

2) Ant Colony Optimization:

In the normally, ants (firstly) wander randomly, and judging food return for his or her colony while put down pheromone trails. If next ants find this type of path, they're possible not to keep traveling randomly, but to in its place track the trail, returning and reinforcing it as long as they eventually get food. After a while, however, the pheromone trail starts to evaporate, thus reducing its attractive strength. The additional time it requires for an ant to see down the trail and rear, the additional time the pheromones need certainly to evaporate. A fast path, in comparison, find marched over more frequently, and therefore the pheromone concentration becomes higher on shorter paths than longer ones. Pheromone evaporation even offers the benefit of avoiding the convergence to a locally optimal solution. If there were no evaporation at all, the paths chosen by the original ants would are often excessively appealing to the next ones. Because case, the exploration of an ideal solution is space could possibly be constrained. Thus, when one ant finds a good (i.e., short) path from the colony to a food source, other ants are susceptible to follow that path, and positive feedback eventually leads to any or all or any the ants' carrying out a single path.

3) Artificial Bee Colony Algorithm (ABCA)

ABCA is based on the behaviour of the bee's environment. No of swarm intelligence algorithms are present. These algorithms are classified on the behavior, foraging behaviour and mating behaviour. Examples of algorithms simulating the foraging behaviour of the bees consist of the Artificial Bee Colony (ABCA), the Virtual Bee algorithm proposed by Yang, the Bee Swarm Optimization algorithm proposed by Drias et al., the BeeHive algorithm proposed by Wedde et al., and the Bee Colony Optimization algorithm planned by Teodorovic and Dell'Orco . An individual entity (e.g., a bee in a bee colony) exhibit a simple set of behaviour

policies (e.g., migration, replication, death), but a group of entities (e.g., a bee colony) shows complex emergent behaviour with useful properties such as scalability and adaptability. Artificial Bee Colony is a predominant algorithm simulating the intelligent foraging behaviour of a honeybee swarm, proposed by Karaboga and Basturk [16].In ABC algorithm, the colony of artificial bees contains three groups of bees: employed bees, onlookers and scouts.

V. LITERATURE REVIEW

Waseem Khan[17] In this article, various techniques of image segmentation has been discussed, an overview of all related image segmentation techniques has been presented in this paper. Recent research in image segmentation techniques is presented in this paper. After the analysis of different techniques of image segmentation, it is observed that a hybrid solution for image segmentation consists of two or more techniques is being the best approach to solve the problem of image segmentation.

Abhay Sharmaet.al [18] Particle swarm optimization is the nature motivated computational search and optimization approach which was produced on the premise of conduct of swarm. As of late every single field of exploration is using the properties of PSO. One of the prominent field of exploration is image segmentation which is likewise quickest developing field. Taking the upsides of joining PSO with diverse image segmentation strategy numerous specialists has proposed different research papers with improvement of different parameter. In this paper we surveyed some paper and attempt to give late patterns and methods included in image segmentation with PSO.

Fahd M. A. Mohsen et.al [19] In this work, PSO has been used to produce a new optimization-based image segmentation method, PSOTH. In the PSOTH method, the algorithm of PSO tries to find a near optimal segmentation for a given image using a fitness function. PSO is a flexible optimization method, where many objective functions can be used. For this reason, a new quantitative evaluation function for segmented images has been proposed in this paper. So in the PSOTH method, the new evaluation function has been used as a fitness function for the algorithm of PSO.

Shi Na et al. [10] conversed the standard k-means clustering algorithm and analyzes the short-comings of standard k-means algorithm,

Such as the k-means clustering algorithm compute in each iteration, the distance between each data object and all cluster centers, which create the efficiency of clustering, was not high. This paper proposes an improved k-means algorithm in order to solve this question, requiring a simple data structure to store little information in each iteration, which was to be used in the next iteration. The enhanced method avoids computing the distance of each data object to the cluster centers repeatedly, reduction the execution time. Experimental results explain that the enhanced method can efficiently get better the speed of clustering and accurateness, dropping the computational complexity of the k-means.

INA SINGH, Optimal Selection of initial clusters is a challenging task in image segmentation. Wrongly selected clusters lead to poor results. We have designed a technique for image segmentation using K-means clustering and Ant colony Optimization for Abdominal CT images to segment the liver region. This technique is much better in segmenting liver than the other models. Thus it is concluded that for abdominal CT images, ACO based K-means clustering is better than many other techniques [20].

VI. CONCLUSION

Image segmentation is a main step in the area of image analysis and compression. The process of dividing an image into multiple regions (set of pixels) is known as Image segmentation. It is detected that there is no any suitable method for image segmentation because the solution of image segmentation is depends on several factors, i.e., texture, pixel color, intensity, matching of images, image content, and problem domain. The paper shows the detailed explanation about how the segmentation is done by using each technique separately. This natural technique of computing provides a number of ways for resolving the real world problems, more efficiently and quickly with accuracy. Among them, ACO has a wide range of applicability which makes it one of the important and efficient techniques for its wide range of applications.

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