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Application of Fuzzy C-Means (FCM) Algorithm in Image Apportionment

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Abstract: *In this paper, we are proposing an analysis of images via the fuzzy c-means (FCM) algorithm by performing the apportionment procedure. In an image apportionment process, images can be treated as an object and divided into sub-images of same classes, labels, and characteristics that belong to the same cluster to investigate meaningful outcomes. There are various techniques for apportionment like thresholding, clustering, interactive segment analysis, compression based, histogram, edge finding, region extension, partial differentiation based, graph-based, multi-scale, watershed, semi-automatic analysis but among these fuzzy c-means (FCM) algorithm is one of efficient technique. In this paper, we are replacing standard fuzzy c-means (FCM) algorithm with improved fuzzy c-means (FCM) algorithm to overcome noise sensitivity. By suggesting, an image segmentation technique with improved fuzzy c-means (FCM) algorithm, we can perform an analysis of images either on picture or video within less time by scrutinizing the similar types of clusters. For generating more accurate results, we'll combine spatial details of images with improved membership function for the clusters. There are multiple areas to apply segmentation procedure like image retrieval, machine vision, object identification, recognition of an object, traffic control system, video Surveillance, video object, and action localization etc. This paper is demonstrating trial results of the distribution of pictures by utilizing enhanced traditional fuzzy c-means (FCM) algorithm in a progressively proficient and exact way.*

Keywords: *Image apportionment, noise sensitivity, membership function, fuzzy, histogram.*

I. Introduction

In this paper, for the segmentation procedure, here we are discussing Fuzzy c-means algorithm (FCM). It's an unsupervised learning approach that can be classified under the learning section of machine learning in learning hierarchy Figure 1. In this, there is a clustering methodology. Although there is various methodologies present for the clustering procedure this particular can be best describes as fuzzy c-means (FCM) algorithm and that can be further subcategorized as per the requirements of the segmentation procedure for different-different data values.

We are basically talking about the image and segmentation of images by using various techniques and by analyzing those images try to figure out the major important outcomes from the respective image. That image can be anything or belongs to any domain like from the medical industry, entertainment industry, hospitality domain, defence sector, an education field etc. By looking at an image just once it's not possible to figure out the exact nature of an image like if we are taking an example of tapeworm analysis in brain in medical sector, it's not possible to find out the problem even while taking a perfect snap of a brain then for a proper investigation of the problem we have to segment the image by using different techniques accordingly like fuzzy c-means clustering, threshold, motion-based, compression based, histogram-based etc.

As we did some little research in image segmentation, we found that there are a number of techniques available and simultaneously there are various regions found to apply these techniques. Every technique is not good for every region like image retrieval, medical imaging, object detection; traffic control system, computer vision, graphical analysis of images and traffic system etc. may be some techniques are good for some region. In this paper, we are reviewing the methodologies of image segmentation and try to figure out the outcomes of the segmentation process.

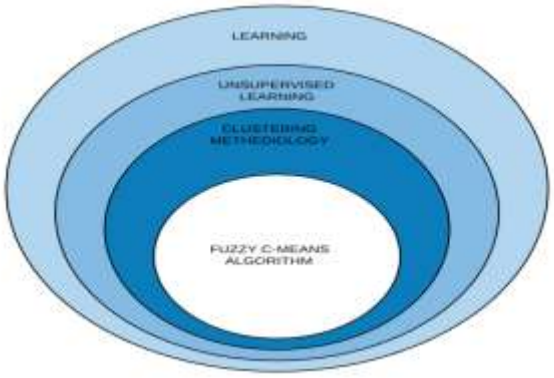

Figure 1 Learning hierarchy

II. Background

Image segmentation is one of the important problems in various applications like computer vision, traffic system, medical image analysis, object detection, pattern recognition, robot imaging etc. To get the exact result from the given image after segmentation procedure, it's more important to select the right technique. In this paper, we are focusing on various image segmentation techniques and their area of applications. We already know that there is a number of techniques available. While applying these techniques, we must have a basic idea about the segmentation process. Images can be of different types like some of having high dimensional quality or low dimensional quality.

Although we are focusing on segmentation technique, right after choosing the best-suited segmentation approach, we need to decide some parameters on which we can apply the segmentation procedure effectively. As per researcher Mr. Vicenç Torra, the University of Skövde, Sweden written on his paper, deciding parameter are very important to every algorithm that is used to define the degree of fuzziness and if the parameters are too larger then class will be blurred, so the solution to this problem is deciding the parameter according to the number of partitions or clusters [1][2].

Fuzzy clustering techniques and its various versions are used successfully in the segmentation process. Now the perspective is changed and inclined towards the quality of the data like low quality, moderate quality or high-quality data etc. While dealing with high dimensional data as per researcher Mr. Roland Winkler and Frank Klawonn and Rudolf Kruse said dealing with high dimensional data is not a very easy task especially if that data is too sensitive and too noisy like data from medical industry. To remove the noise, reduce the parameter and apply the nearest neighbor methodology that will give us the result accordingly [3][4].

One more interesting FCM application in image segmentation explained by the researcher Shanmukhappa Angadi. In his work, he explained the video summarization by using graph representation through FCM. In the procedure, he found to draw the weighted undirected graph and used the concept of the Euclidean distance [5][6]. Some researchers like Yong Yang introduced the panelized fuzzy clustering methodology in which he explained the improved objective function that can able to reduce the noise from the give image data set and provide the desired output [7][8].

s we all know that one can analysis the image by performing various operational techniques and those techniques can be completely based on the area in which that image belongs. For the analysis of an image, segmentation is of the widely used techniques and under the segmentation procedure, it further classified into several of approaches as well. Some of the most frequently used segmentation methods are discussed below in Table 1.

TECHNIQUES	DESCRIPTION	PROFITS
Thresholding	Used to turn a grey scale image into a binary image.	Proving better flexibility to the image for processing.
Clustering method	An iterative technique used the concept of partitioning of an image into clusters.	Allowing datasets to belongs to either one or more clusters.
Motion & interactive segmentation	Worked on matching the compatibility of the object with moving object.	Check the running efficiency with respect to the object from another object.
Compression based segmentation	Performing minimization of all possible segments.	Collaborating segments by analyzing clusters.
Histogram-based method	A recursive technique that divides clusters into smaller clusters.	To get more accurate outcomes.
Edge detection	Can be used where edges and region boundaries are closely related.	To get the desired output as per the specified objects.

Dual clustering method	Used to combine histogram analysis, high compactness and high gradient of an image.	More advanced results.
Region-growing method	Worked on a neighboring region having the same pixel values.	To get a detailed analysis of smoother images.
Partial differential equation based method	Used in curve propagation of object extraction, object tracking, stereo reconstruction etc.	Used while using the concept of the rate in change in pixel while performing the operation.
Variational method	Segmentation process can be done by specific energy functions.	Used in the specific function s like energy one.
Graph partitioning method	Sharing the impact of a neighboring pixel on a given other cluster pixel.	Using one pixel as per the requirement of the image analysis.
Watershed transformation	Worked on gradient magnitude of an image while performing segmentation procedure.	Used for an image having gradient values.
Model-based segmentation	Basically deals with active shape and appearance mode.	On the basis of object appearance, it provides a notable outcome.
Multi scale segmentation	Segmentation can be done in scale space at multiple scales.	Provides a more reliable and flexible image analysis.
Semi-automatic segmentation	Outlines can be drawn by the simple mouse click to select the edge of the image.	Used in the case of mild outlines.
Trainable segmentation	The entire procedure can be done by making trainable data sets.	Get the output in a supervised way of learning.
Segmentation of relatable images & videos	Segmented analysis of correlative images, videos and used in human action localization.	Watch the relatable image analysis.

Table 1 Types of segmentation approaches

III. Methodology

1.1 Traditional fuzzy c-means algorithm

In the clustering environment, fuzzy c-means clustering (FCM) algorithm is the techniques that are used to generate optimal 'c' partitions by minimising the given weights grouped by the objective functions. This methodology was firstly introduced by Dunn and further updated by Bezdek. The algorithm worked on number of data items $X_{i,}$, number of cluster C, a weight exponent of fuzzy membership function Q, a prototype of centre cluster V_i, and distance between the object in data set and cluster centre D^2 etc.

$$J_{FCM} = \sum_{k=1}^{n} \sum_{i=1}^{c} (u_{ik})^q \, d^2 \, (x_k, v_i)$$

[11]

1.2 Modified fuzzy c-means algorithm

In the fuzzy c-means (FCM) algorithm, to increase the efficiency of an algorithm and optimize the outcome produced by traditional FCM, modified FCM introduced. While dealing with the same kind of formulation modified version of FCM is more suitable as compared to traditional FCM.

1.3 Novel multiple kernel fuzzy c-means algorithm

In the different variations of fuzzy c-means algorithm, novel multiple kernel c-means algorithms are also one of the important algorithms used to analysis the image by performing the operations on multiple kernels but the objective function of this algorithm is a bit different from the traditional algorithm functions. The proposed multiple kernel algorithms are very sensitive towards the noise and it doesn't allow sharing spatial neighbor pixel information, so, it'll come up with the spatial biasing concept with biasing.

1.4 Fuzzy c-means threshold algorithm

As per the definition of the threshold concept, fuzzy c-means algorithm follows the same. It provides the vital flexibility to the data sets and allows that data set to entertain itself in multiple clusters at the same time. It'll also show the range in which that data clusters belong. Although it's not new it'll really help to get the more efficient outcome by processing the image. The process will begin with selecting a random cluster center 'c', calculate fuzzy membership values, and perform an operation on the fuzzy center, repeating the entire process until we get the desired results. This approach is also useful in the case of overlapping of segments [2].

1.5 Probability based fuzzy c-means algorithm

While performing image segment analysis there are many factors affecting the process. Especially In the medical industry where every single process needs to be perfect like in Magnetic resonance imagining (MRI), there are some factors like operator performance, external environment, equipment used etc. plays a very critical role while analysis the image. There were algorithms like probabilistic fuzzy clustering, fuzzy probabilistic clustering algorithm used but all of these had some sort of problems. So, In the Figure 2, Probability-based fuzzy c-means algorithm (PFCM) is another form of the algorithm used to resolve the

problem and get the desired outcome [9][10]. The main important role of probability approach is that it'll help to remove the overlapping problems while performing image segmentation, reduce the noise present in the data set and reducing row constraints.

Figure 2 Probability based fuzzy c-means algorithm

1.6 Penalised fuzzy c-means algorithm

While performing image segmentation procedure by using fuzzy c-means (FCM) algorithm, an objective function of traditional FCM doesn't have any spatial information and the entire process can be done independently from pixel values and grey levels of an image that makes algorithm more noise sensitive. To overcome this we need to rectify the process and penalized the spatial information with neighboring expectation maximization (NEM) algorithm and define a new objective function of Penalised fuzzy c-means algorithm (PFCM). New objective function of PFCM can be defined as:

$$J_{PFCM} = \sum_{k=1}^{n}\sum_{i=1}^{c}(u_{ik})^{q}\, d^{2}\,(x_k, v_i) + \gamma \sum_{k=1}^{n}\sum_{j=1}^{n}\sum_{i=1}^{c}(u_{ik})^{q}\,(1-u_{ij})^{q} w_{kj},$$

[7][8]

IV. Result & Discussion

In the image segmentation process where the problem occurred because of local contextual and feature space information, traditional FCM not give us a proper analysis of the segmented image. So, In that case, we will use a penalized fuzzy c-means algorithm (PFCM) that will combine feature space information with contextual information and will produce a better-segmented image for further analysis like in Figure 3.

Figure 3 Comparison of segmentation results on real standard images named place Lena and Cameraman, a) The original images, b) FCM results, c) PFCM results

While performing segmentation of satellite images in Figure 4, it's more convenient to modify traditional FCM rather designing a new clustering approach to maximize the analyze result of an image [12][13].

Figure 4(a) Original image and (b) Segmented Image using FCM algorithm

In graph representation by computing the cluster prototype and calculating distance between the graph and cluster representative, we surely increase the efficiency of traditional fuzzy c-means algorithm (FCM) and generate optimum output. Although, we need to remember some parameters like a number of clusters, fuzziness, the termination tolerance, norm inducing matrix etc.

For the high dimensional image, while performing the image segmentation process, it's important to know the data set and their objective functions. Two approaches like hard c-means (HCM) and fuzzy c-means (FCM) are not suitable for high dimensional images. So, we suggested performing a segmentation process by using polynomial fuzzifier function (PFCM). That will perform quite well.

V. Conclusion

In this paper, we found that there are approaches having their own class of work. There are multiple fuzzy methodologies available like fuzzy c-means, fuzzy c-means with a threshold, probabilistic fuzzy c-means etc. while performing an image apportionment procedure, we found that modified version of FCM is better than traditional FCM. As FCM moves towards the advancement, it can be further classified into another form as well like probabilistic FCM, Fuzzy probabilistic, kernel based, penalized FCM, novel based etc. All approaches are suitable for the segmentation procedure of an image and will guide you with the best outcome as possible but it must be dependent on the factors chosen by us like location of data points, cluster centre, image dimension, membership values, neighbour values, cluster location, cluster density, noise etc. Like in the analysis of satellite images modified FCM provides more concrete results that can be easily seen by the observer and for normal images penalized FCM gave us an efficient outcome.although in some context we clearly say that a particular approach will not suitable for some domain like in case of hard c-means (HCM) and fuzzy c-means (FCM) algorithm we must say that these approaches will not give you an efficient result as per your requirement because of noise likewise for complex and detailed analysis of an image traditional FCM will not a good option so, we'll try some add-on as per the given conditions and generate more concrete, efficient and optimised result of segmentation process. In the future, we'll surely combine some other algorithm and will perform the segmentation process effectively.

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