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A Novel Layer Based Logical Approach (LLA) Clustering Method for Performance Analysis in Medical Images

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Abstract : Nowadays, more researchers choose data mining techniques to find optimal solutions for their chosen data set is a major role in various domains. One of such field is medical field in which some computer oriented approaches are utilized to find the diseases appropriately by its techniques. Particularly, applications of Data Mining (DM) are very well applied for medical data analysis. MRI medical images are given as input in this work for analysis. A novel method named as Layer Based Logical Approach (LLA) is proposed in this research work to test the consistency of different medical images. The LLA approach is compared with the existing *k*-Means and Fuzzy C-Means algorithms for its performance and efficiency. The data set used for this work is preprocessed first and then clustered using these three approaches and then performance is compared with one another. Finally, the best algorithm for the process of MRI medical image is suggested for the prediction of cancer affected regions.

Keywords: Layer Based Logical Approach, Cluster Based Images, Medical Images and Cluster Techniques.

1. INTRODUCTION

In recent decades, efficient detection of brain tumor is being stupendous challenge for medical science. Especially for Magnetic Resonance Imaging (MRI), it is quite concerning content since, MRI image are rarely color image. MRI images have good contrast value over different technique. However, an appropriate segmentation of brain MRI image is apparent for detecting abnormality in brain. As brain comprehends complicated structure, segmentation of MRI image obliges good care and should be precise [1]. Segmentation describes salient image regions to procure Region(s) of Interest (ROI's) such as legions, tumors, edema, and necrotic tissues in brain image [2]. Image Division is an important part of practical and automated image recognition systems, because it extracts the intensity of objects, for further processing such as description or recognition. A cluster is a collection of objects which are similar and are dissimilar to the objects belonging to other clusters [5]. Clustering is an unsupervised analysis technique where data's are divided into different groups known as clusters by keeping in mind two properties High Cohesion and Low Coupling [6]. According to the first property, data belong to one particular cluster must show high similarities [13]. And, the second property says that data items of one cluster should be different from the data items of the other clusters. Clustering is divided into two main types: Hard Clustering (Exclusive Clustering) and Soft Clustering (Fuzzy Clustering or Overlapping Clustering).

Among the clustering algorithm, *k*-Means methods is always the first choice of researcher's because of its simplicity and high performance ability. While, in case of soft clustering, data may exhibit membership values to more than single cluster [14]. Clustering is suitable for image segmentation task. In our approach,

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hard cluster input image data are integrated with soft cluster image data for the prediction of differences clustered layers. These clustered layers are used to find optimal significant regions based on proposed model. This research paper describes the various analysis done on the cluster based input image using the Layer based Logical Approach LLA performance. With these small introductions, the structure of the research paper is organized as follows. Section II gives explores the materials and methods used for this research work and the results and discussion work of this article is given in the section III. Finally, section IV concluded the research work via its findings.

2. MATERIALS AND METHODS

The objective is that items within a group be similar (or related) to alternative and different from (or unrelated to) the items in other groups. There are many cluster method proposed by several researchers in the field of clustering applications. Such algorithms create high impact in their clustering results [11]. This research work is carried out of the properties of the two partition based algorithmic input data, namely *k*-Means and Fuzzy C Means respectively within Layer Based Logical clustering processes are implemented with MRI Brian Images. The basic ideas and concepts are explored in the following sections.

A. Pre-processing Techniques

The main objective of the preprocessing is to develop the image quality to make it ready for further processing by removing or reducing the non related and surplus parts in the background of the medical images. These methods are separated into following categories data cleaning, data integration, data transformation and data reduction. The steps involve the process are Region of Interest (ROI), Inverse Method and Edge Detection for boundary of the image respectively.

B. The *k*-Means Algorithm

The k-Means is one of the simplest unsupervised learning algorithms that solve the well-known clustering problem [15]. Since, *k*-mean clustering [4] is normally introduced to group a set of data points $\{x_1, x_2, \ldots\ldots, x_n\}$ into *k* clusters [16]. It has high computational efficiency and can support multidimensional vectors. So it reduces the distortion measurement by minimizing a cost function as:

$$K = \sum_{j=1}^{k}\sum_{i=1}^{n}\left\|x_i^{(j)} - c_j\right\|^2 \quad (1)$$

where $\left\|x_i^{(j)} - c_j\right\|^2$ is a chosen distance measure between a data point $x_i^{(j)}$ and the cluster center c_j, is an indicator of the distance of the *n* data points from their respective cluster centers. The algorithm is composed of the following steps:

Step 1: Place *k* points into the space represented by the objects that are being clustered. These points represent initial group centroids.

Step 2: Assign each object to the group that has the closest centroid.

Step 3: When all objects have been assigned, recalculate the positions of the *k* centroids.

Step 4: Repeat steps 2 and 3 until the centroids no longer move.

This produces a separation of the objects into groups from which the metric to be minimized can be calculated. The k-means is simple clustering algorithm that has been improved to several problem domains.

C. The Fuzzy C Means Algorithm

The fuzzy C-means (FCM) algorithm uses fuzzy clustering method based to minimize the quadratic criterion where clusters are formed by signified a particular centres [3]. Fuzzy clustering is a powerful unsupervised technique to analysis the data and to construct effective models [7]. In several situations,

fuzzy cluster algorithm is further regular than hard clustering. The main limitation of FCM algorithm is all about its sensitivity towards noises. FCM implements the clustering task for a data set by minimizing an objective-function subject to the probabilistic constraints that the summation of all membership degrees that result the data point to be focused to one centre. This constraint results in the problem of membership assignment, that is noises are treated the same as points which are close to the cluster centers. The FCM clustering algorithm allows one piece of data to belong to two or more clusters [8]. This method is widely used in pattern recognition. It is based on minimization of the following objective function.

$$F_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m} \| xi - c_j \|^2, 1 \le m < \infty \quad (2)$$

$$u_{ij} = \frac{1}{\sum_{k=1}^{c}\left[\frac{\| x_i - c_j \|}{\| x_i - c_k \|}\right]^{\frac{2}{m-1}}}, c_j = \frac{\sum_{i=1}^{N} u_{ij}^{m}.x_i}{\sum_{i=1}^{N} u_{ij}^{m}} \quad (3)$$

Where m is any real number greater than 1, x_i is the i^{th} of d-dimensional measured data, c_j is the d-dimension center of the cluster, u_{ij} is the degree of membership of x^i in the cluster j, and || * || is any norm expressing the similarity between any measured data and the center [17]. Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centers c_j.

This iteration will stop when, $\max y\{| u_{ij}^{(k+1)} - u_{ij}^{(k)} |\} < \xi$ where ξ is a termination criterion between 0 and 1, whereas k is the iteration steps. This procedure converges to a local minimum or a saddle point of Fm. The algorithm is composed of the following steps:

Step 1: Initialize U = $[u_{ij}]$ matrix, $U^{(0)}$

Step 2: At k-step: calculate the centers vectors C(k) = $[c_j]$ with U(k)

Step 3: Update U(k), U(k + 1)

Step 4: If $\|U^{(k+1)} - U^{(k)}\| < \xi$ then STOP; otherwise return to step 2.

D. Layer Based Logical Approach (LLA) Clustering

LLA clustering method is used to predict optimized significant region of medical data, through preprocessing using density based ROI, inverse method and bounded detection techniques. The results of k-mean, FCM are unsupervised and used for cluster layer generation. Subsequently the select minimum pixel value of the k mean has to be weighted to process with FCM techniques with different clustered layers. The layer based clustering process model has been show in Figure 1 and 2.

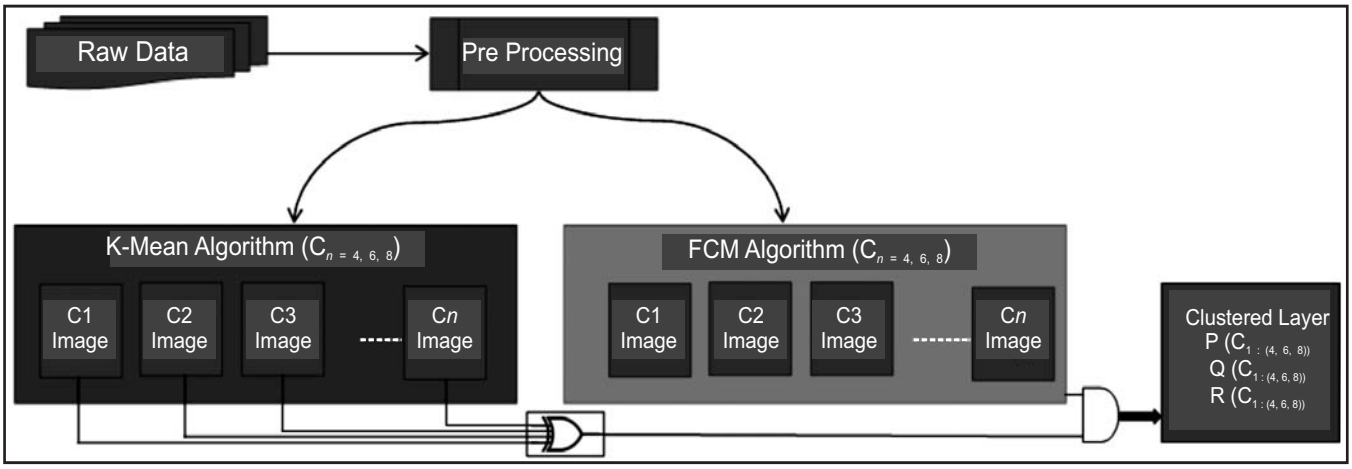


Figure 1: Clustering Process

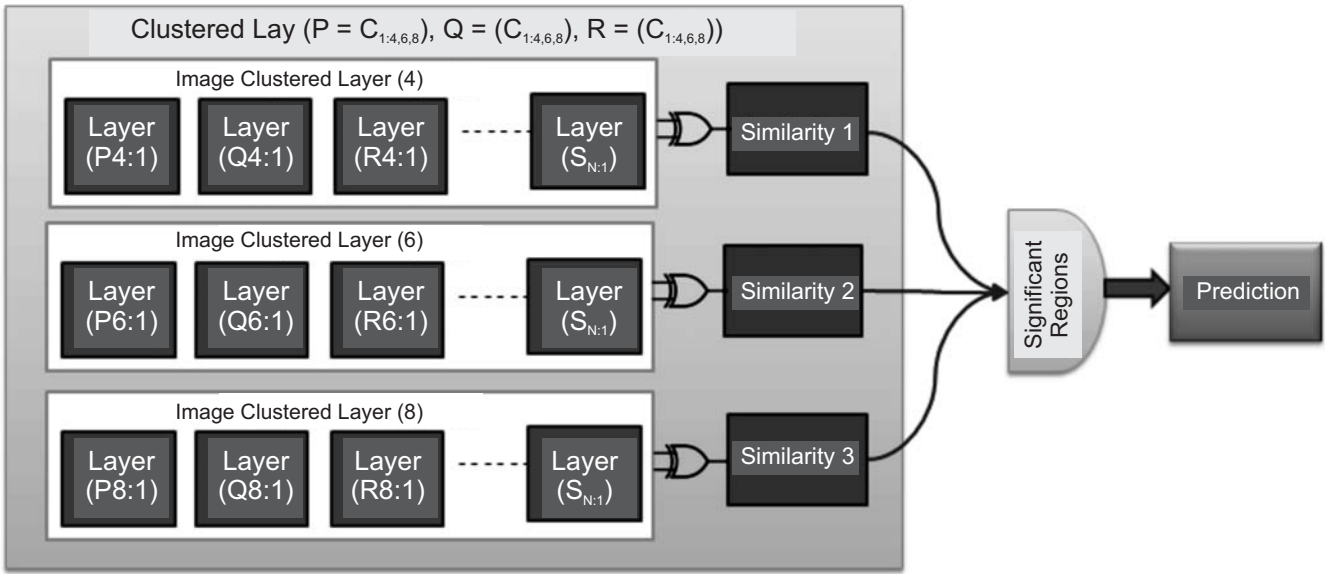


Figure 2: Proposed Architecture

This LLA model has be accumulated in given mathematical equation

$$\text{LLA I} = \sum_{i=0}^{n}\sum_{j=0}^{m}\left|\frac{\text{KI}_{ij}\,\text{S}_{ij}/\text{F}_{ij}}{\left[\text{KI}_{11}\,\text{S}_{11}/\text{F}_{11}+\text{KI}_{12}\,\text{S}_{12}/\text{F}_{12}+.....\text{KI}_{nm}\,\text{S}_{nm}/\text{F}_{nm}\right]}\right|^{1/nm} \tag{4}$$

The LLA clustering techniques are derived by using above mathematical equation 4. These steps involved in cluster the raw data by the Layer Based Logical Approach Cluster method are given below.

Step 1: Initialize I_{ij} = [I] matrix, $\text{I}^{(0)}$ from Preprocessed

Step 2: To identify the best cluster point R = min[$|\text{I}_1|$, $|\text{I}_2|$, $|\text{I}_3|$ .....$|\text{I}_n|$] *k* means of clustering

Step 3: Integrate difference of $\text{D}_{ij} = \sum_{\text{R}}\left(\sum_{j=0}^{n} dif\,(\text{I}_j)\right)$ image using R *k*-Means with j^{th} FCM

Step 4: To identify the best cluster point in S_i = min(D_j) from step 3

Step 5: Till $i > n$ then Stop; otherwise return to step 2.

Step 6: To integrate $\int_{i=0}^{n}\text{S}_n$ into LLA Cluster images

This algorithm will lease to determine signification area of MRI brain image. The initial image preprocessed and clustered using k-means and FCM algorithms. The clustered image shows similar high density region which represents irregular image. The common irregular determined images are unified using logical operators as part of *Layer Based Logical Approach.*

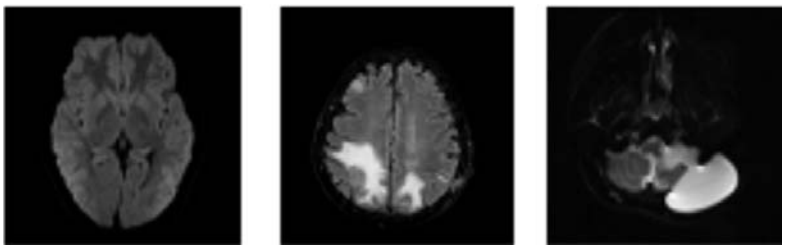
3. RESULTS AND DISCUSSION

In the execution of this proposed research work, the clustering algorithm uses MRI brain images as input. Subsequently, detailed discussions of information about the experimental results of clustering algorithm are presented in this section.

A. Description of Data Set

Medical imaging refers to several different technologies that are used to view the human in order to diagnose, monitor, or treat medical conditions [9]. The Magnetic Resonance Imaging (MRI) is a medical imaging procedure for making images of the internal structures of the body. MRI scanners use strong magnetic fields and radio waves (radiofrequency energy) to make images. The signal in an MR image

comes mainly from the protons in fat and water molecules of the body. In this research work is done to analysis the MRI of human brain dataset. The MRI Brian image is three categories: normal, benign and malignant. But this research has been done only on malignant images. The MRI brain images are collected from Swamy Vivekananda Diagnostic Centre (SVDC) – Lab at Arumbakkam, Chennai in Dwaraka Doss Goverdhan Doss Vaishnav College Campus [10]. The Data are indicated normal and the abnormality status of the MRI brain images are marked by SVDC Lab. The taken experimental data are shown in figure 3.



(*a*) (*b*) (*c*)

Figure 3: Original images (*a*) Normal (*b*) Benign (*c*) Malignant

4. RESULT OF PRE-PROCESSING TECHNIQUES

This preprocessing of the result has widely used data mining techniques. This process was done by using ROI, inverse method and edge detection method respectively. The ROI method finds the areas of images based its intensity. The inverse method is used to convert the black colors into white and white color into black color, using the values 0 to 255.The edge detection method fixes the boundary that fit for the image clustering by layer based logical approach algorithm. The result of pre-processing is shown in figure 4.

(*a*) (*b*) (*c*)

Figure 4: Preprocessed MRI Brian Image (*a*) Normal (*b*) Benign (*c*) Malignant

C. Result of LLA Cluster

This method gives the best optimized significant region in various clusters based on layer Based Logical Approach (LLA). The objective of clustering is to divide into a set layers of different variation groups. The clustering of items is based on evaluating of correspondence between the objects using distance function. Thus, effect of clustering is a set of clusters, in a single clustered layer supports similar to each other cluster layers. The proposed LLA were carried out in the MATLAB software. The LLA used medical data in different levels as Normal, Benign and Malignant. The results of K-means, FCM and LLA methods by taking the number of clusters as 4,6 and 8 are shown from figures 5 to 7. In figure 5, grary color backgroud images are the output of *k*-Means algorithm, green color bacground figures are the output of FCM algorithm and merun color bacground images are the output of LLA algorithm. The best output of *k*-Means algorithm is taken for analysis and compared with all the four existing output of FCM. After this process, a comman more significant region is identified by LLA algoritham and then it produce an output which is better than the other results. Like, the process continues to until to get an appropriate affected image. Next as shown in figure 6, the best result of *k*-Means algorithm is compared with the ouput of all the six FCM algorithm as fixed a priori, then the the resultant output image is given to the LLA algorithm. After this process, the LLA algorithm produce one best resultant image, which is the most significant image. Like, in figure 7, the FCM algorithm results are fixed as 8 and the best of *k*-Means is taken for

analysis, then the LLA algorithm produce one output as shown in figure 7. The various steps of entire processing is discussed as follows.

Step 1: Given the original image for preprocessing

Step 2: Apply ROI covariance method

Step 3: Apply Inverse method to identify the appropriateness of the image

Step 4: Use Boundary method to detect edges.

Step 5: Segment the image using *k*-Means and FCM

Step 6: Identify the best clustered image by *k*-Means clustering

Step 7: The best *k*-Means clustering image is considered to compare with the FCM outputs

Step 8: The best result produced by previous step taken as input by the LLA algorithm

Step 9: Next, change the number of images into 6 and 8 in FCM. Continue the process

Step 10: The results are tabulated in tables and shown in figures

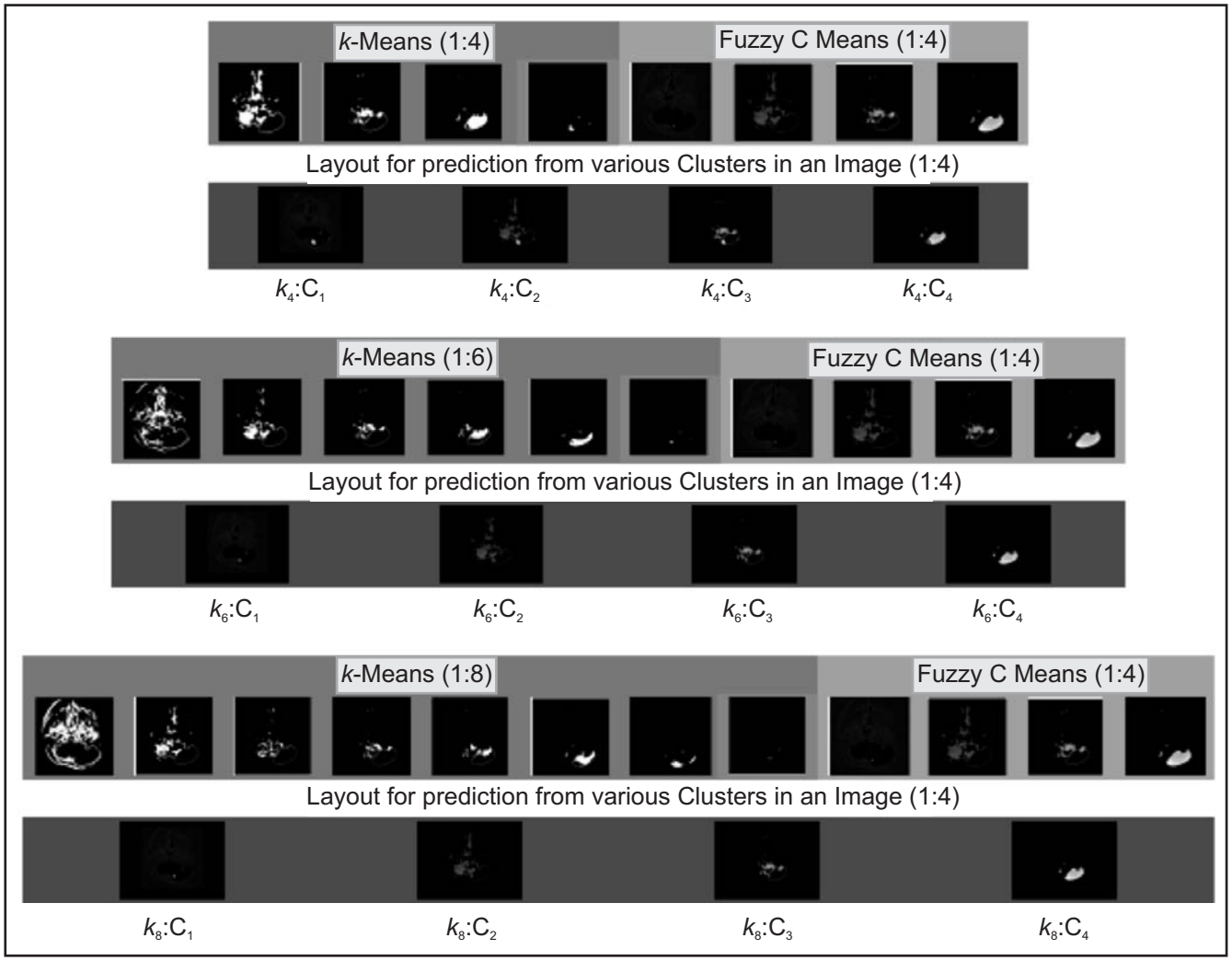


Figure 5: Output of Malignant image for Similarity layers D1 when *k* = 1:4

Only the malignant images are taken for analysis in this process. The best results of figures 5 to 7 are D1, D2 and D3 which is shown in figure 8. Combining these three images and then a new image is derived; it is shown in the same figure 8 at the bottom of the figure. Like, for the entire processing work is carried out by taking benign and normal images and the results are given in figure 9 and figure 10 respectively. The process time and space occupied by the k-Means and FCM algorithms are tabulated in table 1 for all the three types of images. Similarly, table 2 has results of LLA algorithm. In these tables the numbers of white color pixels are given as number of significant objects.

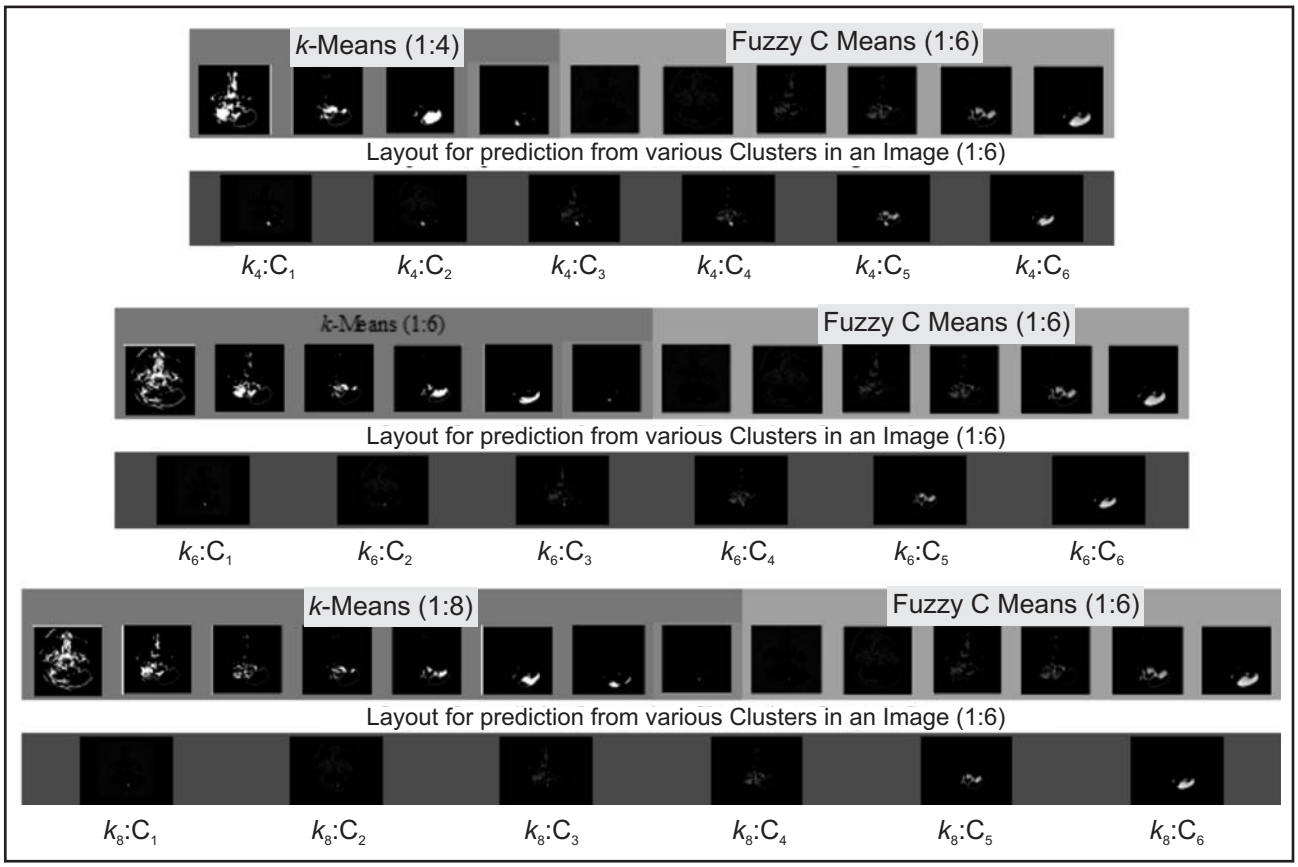


Figure 6: Output of Malignant image for Similarity layers D2 when *k* = 1:6

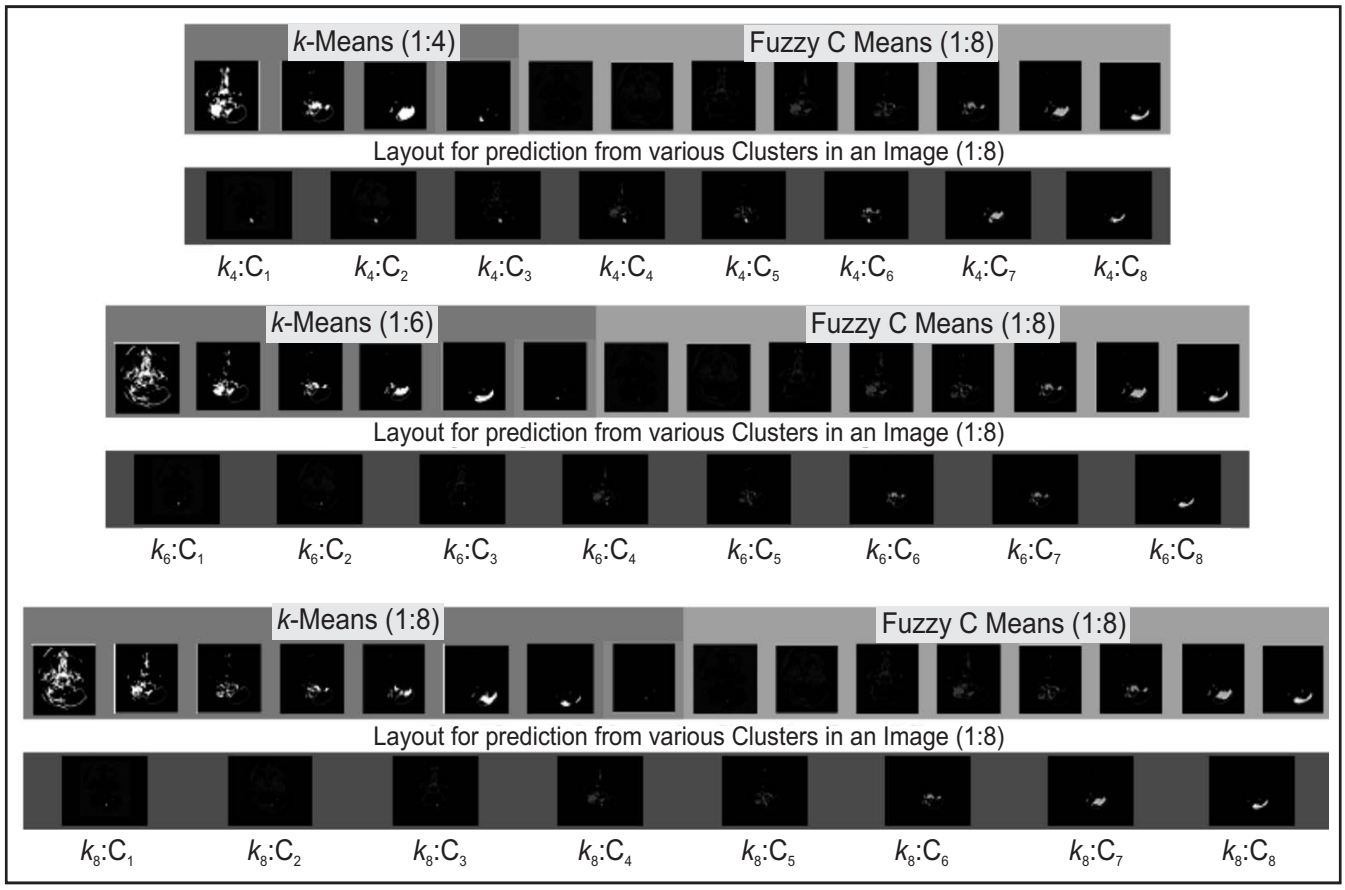


Figure 7: Output of Malignant image for Similarity layers D3 when *k* = 1:8

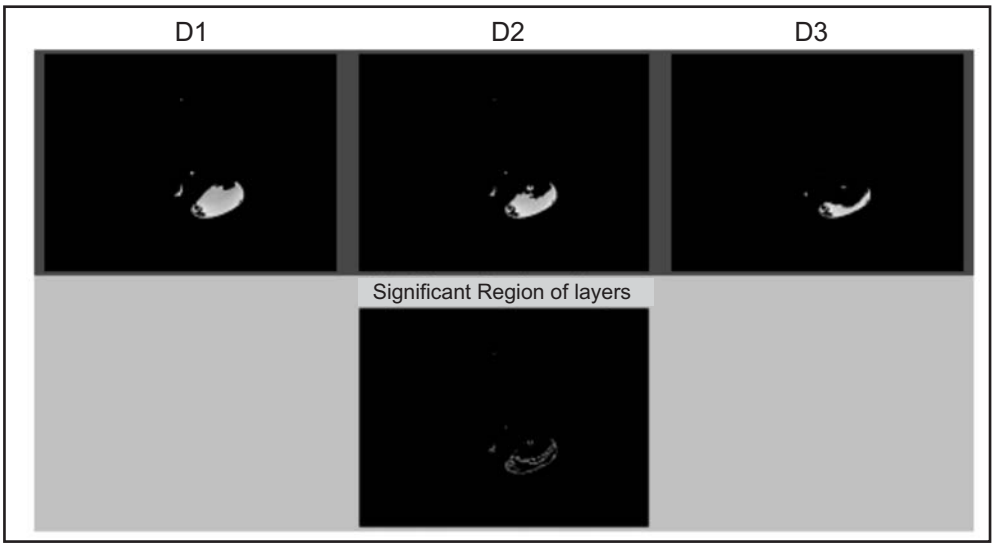


Figure 8: Result of Malignant image

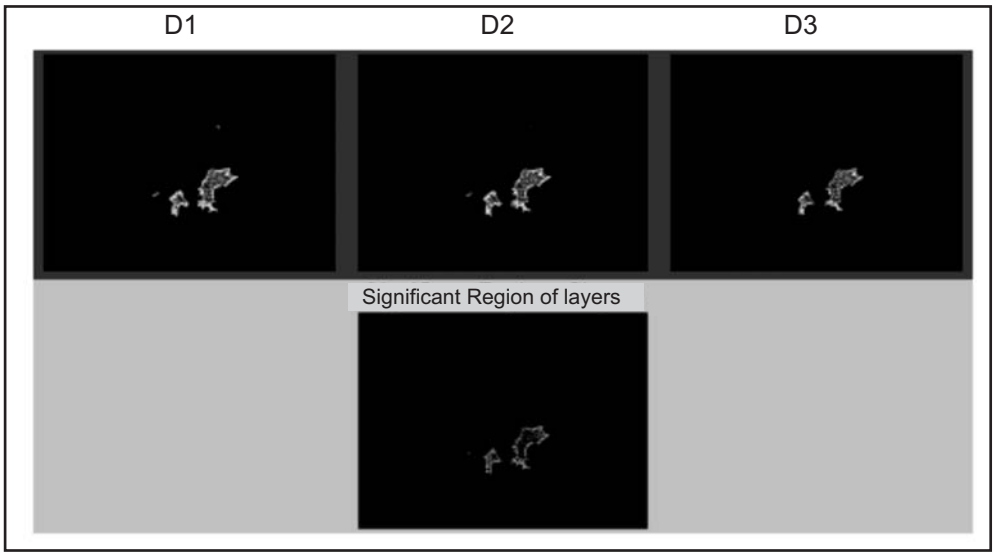


Figure 9: Result of Begin image

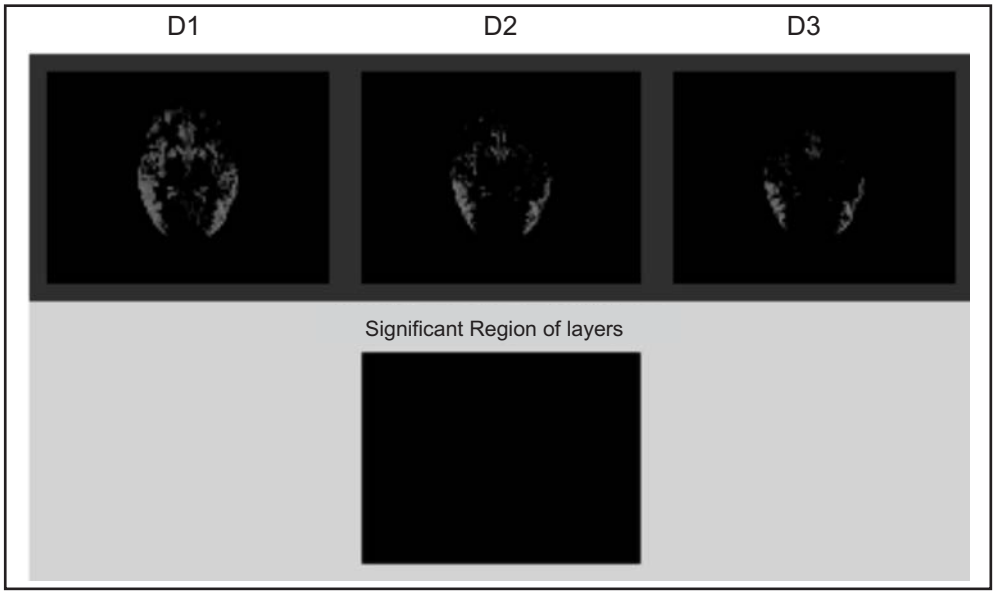


Figure 10: Result of Normal image

Table 1
Result of *k*-Means and FCM algorithm

		k-means			*FCM*			*Average*	
Cluster Values		4	6	8	4	6	8	k-means	FCM
Normal Image	Run time in milliseconds	2870	1503	1587	18125	29952	36816	1987	28298
	Memory in KB	24.8	23.2	22.1	43.4	34.4	30.4	23.36	36.06
	Number of Significant objects	888	329	41	28136	11805	7169	419.333	15703.333
Benign Image	Run time in milliseconds	1166	1084	1392	19249	26039	35686	1214	26991
	Memory in KB	26.4	25.4	24.4	26.7	26.6	26.2	25	27
	Number of Significant objects	4397	1972	800	8946	8349	7347	2389.667	8214.000
Malignant Image	Run time in milliseconds	1394	1082	1567	17435	26655	36341	1348	26810
	Memory in KB	23.2	22.5	22.2	25.2	24.8	24.8	22.63	24.93
	Number of Significant objects	789	230	113	10716	5604	4624	377.333	6981.333

Table 2
Result of LLA Algorithm

LLA						
Cluster Values		*Difference layers*				*Significant Region*
		1:4 (D1)	*1:6 (D1)*	*1:8 (D1)*	*Average*	
Normal Image	Run time in milliseconds	94	51	48	64	892
	Memory in KB	40	31	27	32	21
	Number of Significant objects	16243908	7485159	4744623	9491230	4196
Benign Image	Run time in milliseconds	779	50	47	292	334
	Memory in KB	28	27	27	27.33	31
	Number of Significant objects	6773814	6195951	5140425	6036730	7747
Malignant Image	Run time in milliseconds	92	51	47	63	188
	Memory in KB	21.7	21.1	21.0	21.27	27.5
	Number of Significant objects	11373594	6037626	4925019	7445413	6822

The pictorial representation of average runtime for normal, benign and malignant images is shown in figure 9. It is easy to identify that the runtime is very less in LLA algorithm and it is high for FCM algorithm. Similarly, the pictorial representation of memory is given in figure 10.

5. CONCLUSIONS

The performance of *Layer Based Logical Approach* (LLA) algorithm is well to determine the significant area of the irregular brain MRI images. The hybrid model of clustering and unification of logical processing provided the significant area which leads to processing of further determination and mainly used in medical applications. First, this approach used k-Means and FCM algorithms for clustering and then the LLA algorithm is applied. The common area identified by the LLA algorithm gives the significant

result in this research work. The missing part of the significant area compared with high dimensional level of clusters and the common area is derived. This technique is implemented with logical operations in particularly various levels of clustered data into optimal significant region by using logical gates which determine the significant region and it could be analyzed with performances. The particular area of affected region in MRI images is exactly clustered by LLA algorithm very perfectly compared with k-Means and FCM algorithms. The further work of the research is to continue the validation of the significant area for multiple datasets.

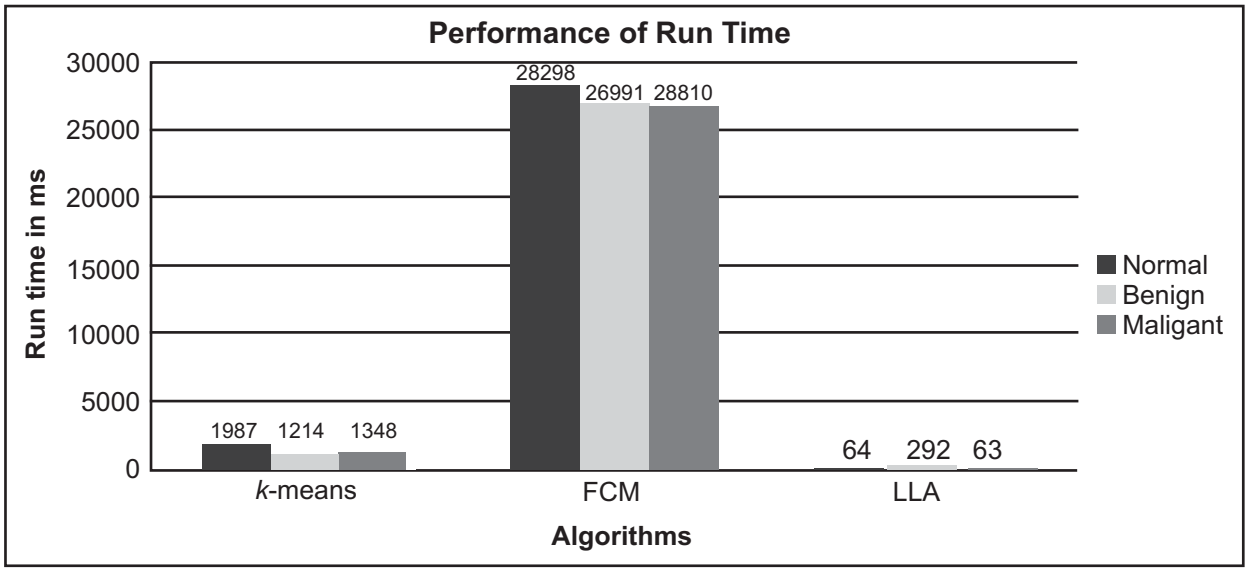


Figure 9: Performance of Run time

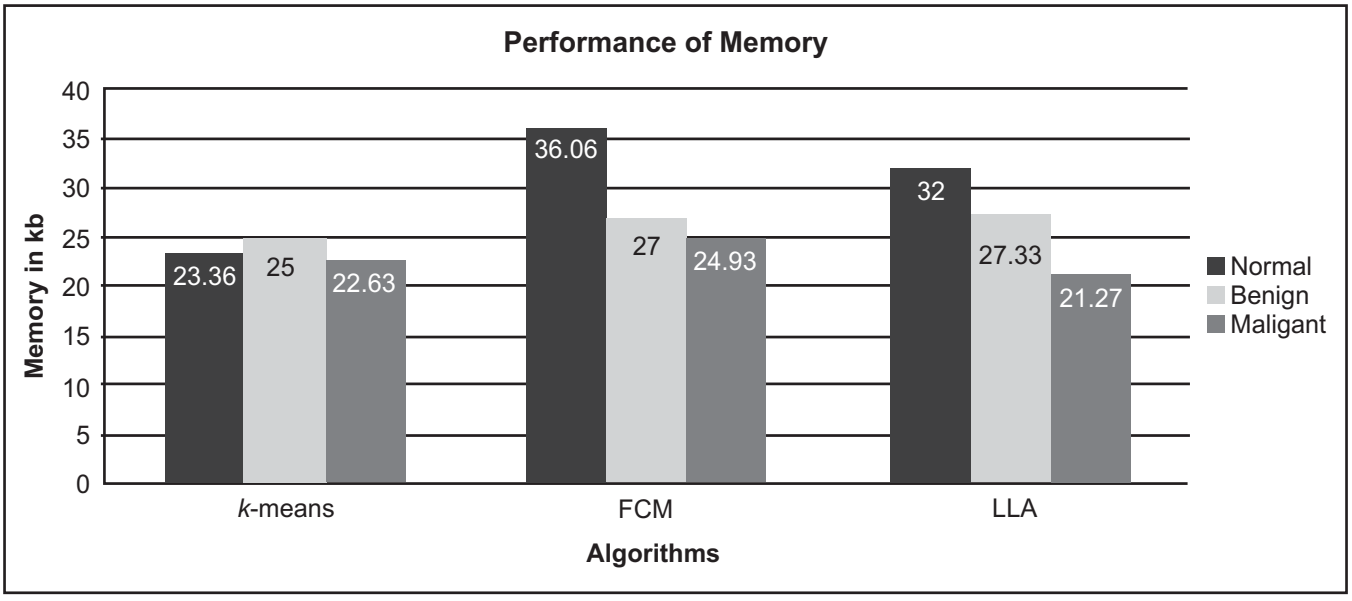


Figure 10: Performance of memory

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