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Images Analysis by Using Fuzzy Clustering

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Abstract:

The Fuzzy C-Mean algorithm is one of the most famous fuzzy clustering techniques. The process of fuzzy clustering is a useful method in analyzing many patterns and images. The Fuzzy C-Mean algorithm is widely used and based on the objective function reduction through adding membership values and the fuzzy coefficient. The Mean Absolute Error (MAE) was also measured in this research for each execution.

The research found that when the number of clusters increases, the mean absolute error value is reduced. When the number of clusters increased. The more details in the resulting image were not present in the original image. This helps in the analysis of the images.

In this research, medical images were treated and analyzed. The analysis helps physicians explain the patient's health status and also according to suggested algorithm helps them to diagnose the possibility of a particular disease or tumor. A Matlab program was created to perform the analysis.

Keywords:
Fuzzy clustering, Fuzzy C-Mean Algorithm, Matlab Language, Image analysis, Mean Absolute Error.

Introduction:

Image analysis involves processing image data to determine the information needed to solve problems. The process of image analysis is the process of converting objects in the image data to quantitative information which derive and describe the object from its image and is usually flexible. The end result is high level information [1].

Medical images play a key role in helping to detect and diagnose many diseases. Medical imaging now provides advanced imaging techniques that enable the physician to see human bodies directly and monitor micro anatomical changes [2].

Methods:

In this research, Fuzzy C-Mean Algorithm (FCM) was used to analyze three medical images.

Fuzzy Clustering:

Fuzzy clustering is an extension of the analysis of the traditional techniques group, [3] and is usually used when there is no apparent grouping in the data set. The essence of the algorithm is the use of iterative processes because the number of steps to obtain the output is not predefined [4]. The objective of the fuzzy clustering method is to define each cluster by looking for its own membership function [5][6].

The performance of the clustering algorithm is affected by the initial values chosen at execution, so the algorithm is repeated a number of times to obtain the appropriate results[7]. The results obtained by the researchers showed that the results were of much higher quality than the use of traditional methods [8].

Fuzzy C-Mean Algorithm (FCM):

FCM is also called Fuzzy ISODATA. This method was developed by Dunn (1973) and improved by Bezdek (1981) [9]. FCM algorithm is one of the most effective algorithms of fuzzy clustering. It is based on the principle of fuzzy logic. It allows each data point to belong to the cluster at a membership degree, so that each data point can belong to several clusters at the same time and with different membership degrees between 0 and 1[10] [11].

The aim of FCM is to find cluster centers in the feature space that minimize an objective function. The objective function is associated with the optimization problem, which minimizes within class variation and maximizes variation between two classes [12].

This algorithm is widely used in image processing applications such as medical imaging and remote sensing. It is a local search optimization algorithm [13].

The FCM algorithm assign a membership for each data point. By calculating the distance between the cluster center and the data point. More the data is near to the cluster center more is its membership towards the particular cluster center. After each iteration membership and cluster centers are updated [14].

The steps of Fuzzy C-Means Algorithmic is:

1. Input original image

Let $X = \{x_1, x_2, x_3 \ldots, x_n\}$ be the set of pixels image and $V = \{v_1, v_2, v_3 \ldots, v_c\}$ be the set of centers.

2. Randomly select *'c'* cluster centers.

3. Calculate the fuzzy membership $'\mu_{ij}'$ using equation (1):

$$\mu_{ij} = 1 / \sum_{k=1}^{c} (d_{ij} / d_{ik})^{(2/m-1)} \quad \text{--- (1)}$$

4. Compute the fuzzy centers $'v_j'$ using equation (2):

$$v_j = \left(\sum_{i=1}^{n} (\mu_{ij})^m x_i\right) / \left(\sum_{i=1}^{n} (\mu_{ij})^m\right) \quad \text{---(2)}$$

Where:

'n' is the number of data points.

'vj' represents the j^{th} cluster center

'm' is the fuzziness index m € [1, ∞].

'c' represents the number of cluster center.

5. Repeat step 3) and 4) until the minimum *'J'* value is achieved or $||U^{(k+1)} - U^{(k)}|| < \beta$.

Where:

'k' is the iteration step.

$'\beta'$ is the termination criterion between [0, 1].

$'U = (\mu_{ij})_{n*c}'$ is the fuzzy membership matrix.

'J' is the objective function.

6. end [15][16][17].

Evaluation Performance Factors:

- **Mean Absolute Error (MAE)**: It is used in statistic to measure the difference between two continuous variables. MAE is defined in equation (3) as followed:

$$\text{---(3)} \quad \mathrm{MAE} = \frac{1}{n}\sum_{j=1}^{n}|y_j - \hat{y}_j|$$

Where: y_j=Original image, $\hat{y}_j$=Output image. Minimum value of MAE indicate that best result, because it include the minimum difference between the original image and output image [18].

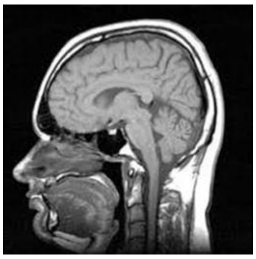
Suggested Algorithmic:

The following algorithm was proposed to execute Fuzzy C-Mean Algorithm and compute the Mean Absolute Error (MAE) values for medical images. This algorithm is:

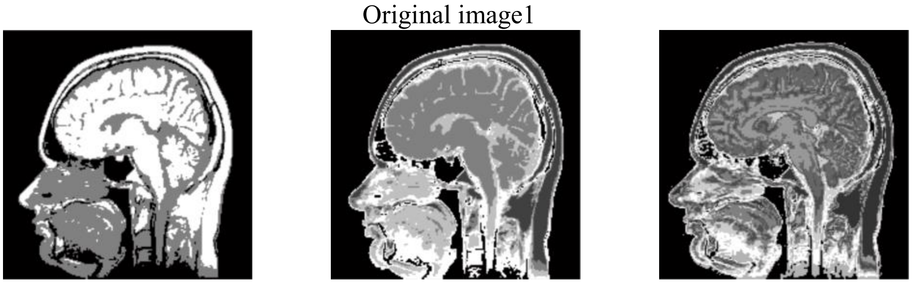
1.Input medical image
2. Input number of clusters (in this research, number of clusters are equal 3 or 5 or 9)
3. Display original image
4. Randomly select *'c'* cluster centers.
5.Calculate the fuzzy membership 'μ_{ij}'
6. Compute the fuzzy centers 'v_j'
7. Repeat step 5) and 6) until the minimum 'J' value is achieved or $||U^{(k+1)} - U^{(k)}|| < \beta$.
8. Display output image
9. Compute Mean Absolute Error value (MAE) between original image and result image.
10. end

Results and Discussion:

After applying the suggested algorithm to the three medical images, The details of result image were better than the original image. These details are increased by increasing the number of clusters entered. These details help the doctors to diagnose and analyze the disease. The results of executing the suggested algorithm were shown in (Figure 1-3) and (Table 1). The graph of MAE values for Image 1, Image 2 and Image 3 were show in (Figure 4-6). In each execution. The mean absolute error value was measured. It was observed that; the greater number of clusters, the lower of the mean absolute error value.

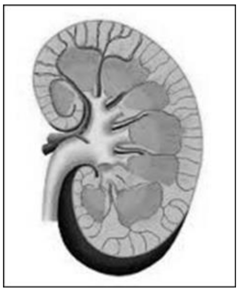


Original image1

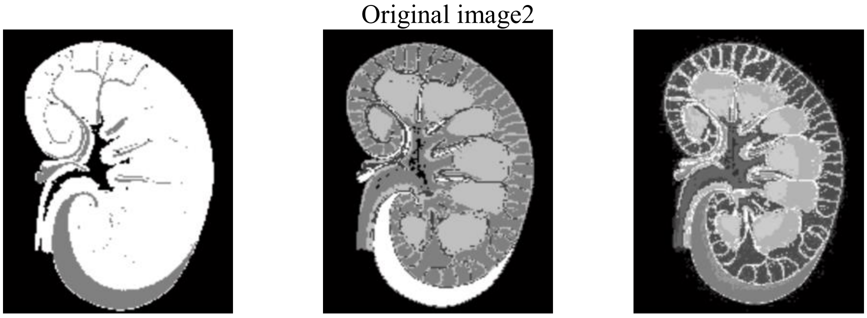


Number of Cluster=3 Number of Cluster=5 Number of Cluster=9

Figure 1: Many cases of image1 after execution FCM algorithm

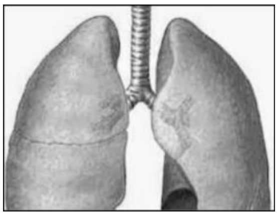


Original image2

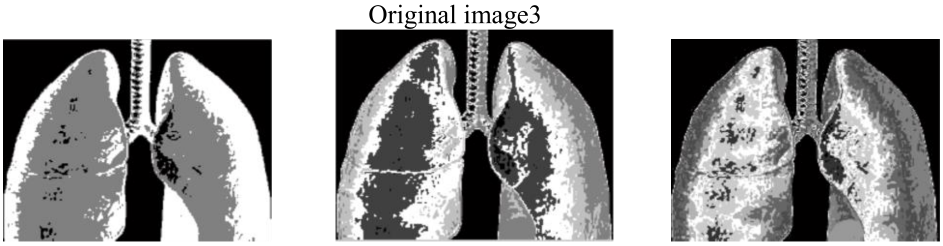


Number of Cluster=3 Number of Cluster=5 Number of Cluster=9

Figure 2: Many cases of image2 after execution FCM algorithm



Original image3



Number of Cluster=3 Number of Cluster=5 Number of Cluster=9

Figure 3: Many cases of image3 after execution FCM algorithm

Table 1: Represent the results of execution the suggested algorithm and compare of MAE values in Image1, Image2 and Image3

Image Name	Size of Image	Number of Cluster	Center	Number of Iteration	Objective function values	Mean Absolute Error (MAE) Values
Image1	100, 100	3	105.2387 187.0227 8.9424	44	13180088.894	107
		5	69.6341 246.6715 167.5079 115.6076 6.3039	83	2863516.246	103
		9	249.0573 67.6441 93.2786 36.8996 181.8289 141.7170 163.9570 116.2323 5.1436	100	842195.516	93
Image2	100, 150	3	160.8961 41.9683 252.3240	32	11468903.771	137
		5	187.1260 108.0396 149.1992 28.6357 253.7071	100	2762756.947	96
		9	116.6543 24.0148 204.9843 73.3078 141.8892 242.4896 158.7911 184.0614 254.5403	100	1021515.375	86
Image3	150, 120	3	112.8440 177.8164 244.5405	40	11317475.414	121
		5	95.1411 131.3992 162.8970 192.6521 246.0111	100	3546875.560	107
		9	140.0731 192.1150 211.6600 117.5321 96.7130 158.6914 176.3608 246.6349 53.2349	100	1048110.728	98

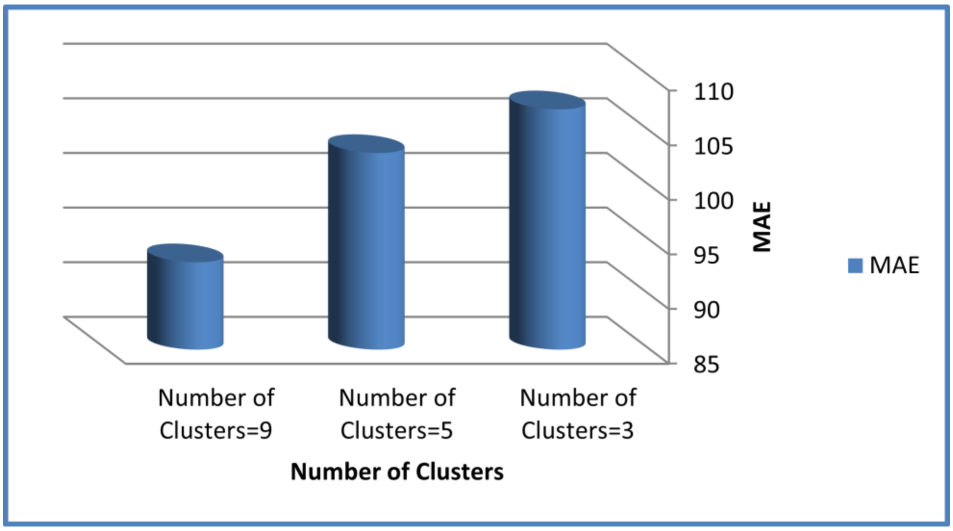


Figure 4: Mean Absolute Error (MAE) of Image 1

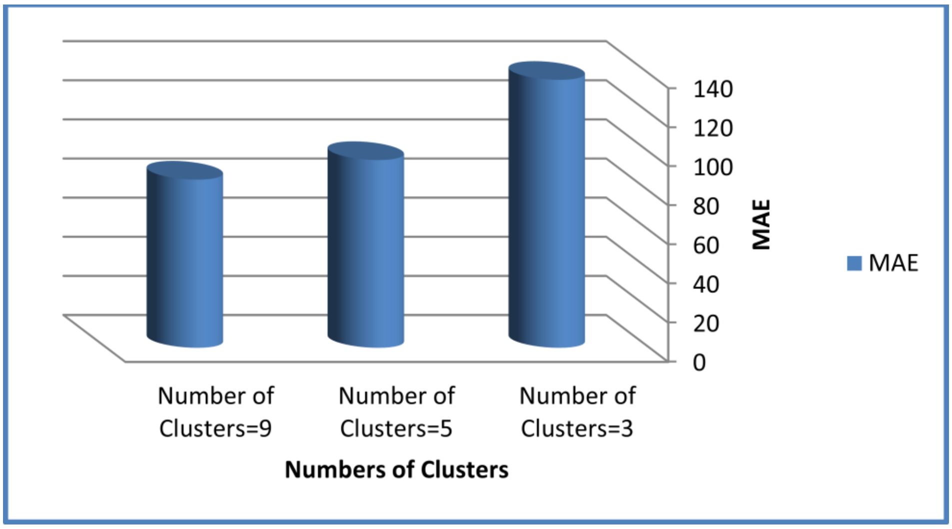


Figure 5: Mean Absolute Error (MAE) of Image 2

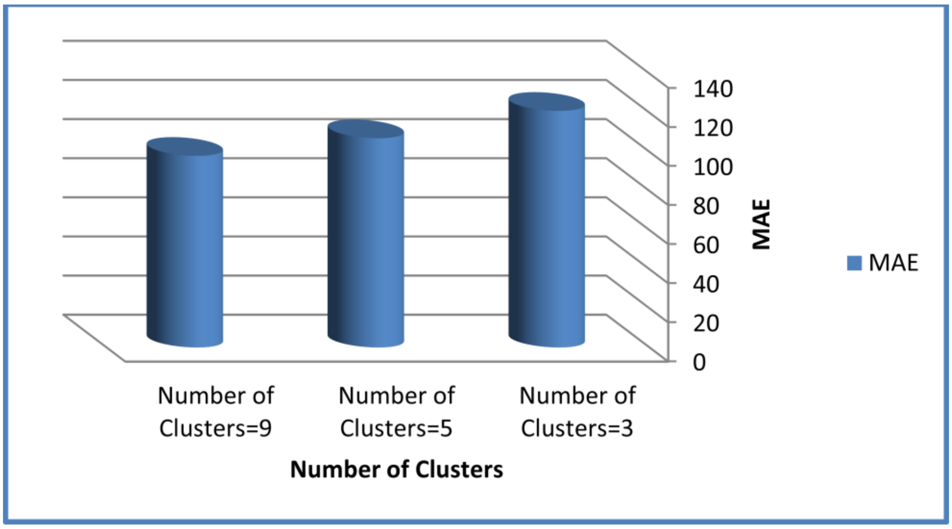


Figure 6: Mean Absolute Error (MAE) of Image 3

Conclusion:

Medical image analysis is currently an important subject in modern medicine. In view of the increasing number of patients as it helps the doctor or the person concerned to give a preliminary idea of the patient's condition without any operation or surgical intervention.

FCM algorithm is the most popular fuzzy clustering algorithm and extensively used in medical image. In this research, used FCM algorithm to analysis medical images. This algorithm provide few iterations steps already provide good approximation to the final solution.

After execution of the proposed algorithm, it was concluded that by increasing the number of clusters in the Fuzzy C-Mean algorithm, the Mean Absolute Error (MAE) values was reduced. The suggested algorithm gave good results in image analysis to help doctors to diagnose and identify the disease.

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تحليل الصور باستخدام العنقدة المضببة

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المستخلص:

تم في هذا البحث استخدام خوارزمية (Fuzzy C-Mean) والتي تعد من أشهر تقنيات العنقدة المضببة. تعد عملية العنقدة بالمنطق المضبب طريقة مفيدة وجيدة في تحليل العديد من الأنماط والصور، وخوارزمية (Fuzzy C-Mean) تستخدم بشكل واسع وتكون مبنية على أساس تقليل الدالة القياسية وذلك بإضافة قيم العضوية ومعامل التضبب. كما تم قياس معدل الخطأ المطلق لكل حالة تنفيذ.

توصل البحث إلى أن عند زيادة عدد العناقيد المدخلة تقلل قيمة الخطأ المطلق المحسوبة، كما أنه بزيادة عدد العناقيد تظهر تفاصيل أكثر في الصورة الناتجة لم تكن موجودة في الصورة الأصلية وهذا يساعد في تحليل الصور.

تم التعامل مع الصور الطبية في البحث وتحليلها وفق الخوارزمية المقترحة. تساعد عملية التحليل الأطباء في تفسير الحالة الصحية للمريض وتساعده أيضاً على التشخيص كاحتمالية الإصابة بمرض معين أو ورم. كما تم عمل برنامج بلغة ماثلاب (Matlab) لتنفيذ عملية التحليل.