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Analyzing and processing medical images with increased performance using fractal geometry

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ABSTRACT

The research relied on the application of a series of steps to analyze medical images, and to basically achieve this goal, a set of techniques were made from both fractal engineering and tissue analysis by improving the studied image and then analyzing the studied image texture in the fractal dimension and propose a hybrid method for segmenting images of complex situations and structures based on the geometric patterns that are repeated and represented by the fractal filter (Hurst), which is one of the modern techniques used in the field of digital image processing. Using fractal methods, that is, a specific application through real fractal structures of medical images and measuring their fractal dimensions and in capturing the exact features based on the scale in dimensional fractions, where the accuracy rate reached (98%) in diagnosing pathological conditions with an error rate close to zero. Also, the coefficients of multiple fractals were calculated (α) ,with a threshold factor of (4.5), the texture is also classified based on the fractal algorithm and Gray-Level Co-Occurrence Matrices (GLCM) and according to the experimental results performed on the medical images, the classification method provides a classification rate of 95%. To increase the accuracy, the lacunarity was calculated in the healthy medical images by applying fractal theorem filters where the gap ratio was close to (1) in the lacunarity size. The results also showed that the decrease in the contrast of the image with the continuation of the smoothing process or the decrease in the intensity levels of the image causes a significant decrease in the contrast of the image, especially in the areas of the edges.

Keywords: lacunarity, medical images, filter, multifractal, texture, Gray-Level Co-Occurrence Matrices (GLCM)

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1. Introduction

An image is a description of how the optical sensitivity factor changes on a given surface. Standard images usually result from alterationThe light intensity is across a two-dimensional plane, and the usual normal images are caused by the sensitivity of the light signal byChemical sensors[1]. Multiple devices and sensors were also used to produce images, such as the thermal camera, which relies on infrared radiation in the imaging process, synthetic aperture radar devices and other types of radars for imaging, using microwaves, as well as sound and ultrasound waves in the production of medical images[2].

The images carry information represented in the two-dimensional domain spatial, as the characteristics and features in the image are represented in the edges, and this means that the distances between the image elements (Pixel Spacing) and their number are determined by representing the smallest details that need to be changed by the process of dividing The image is divided into small elements, each of which is called a pixel[3]. The spatial clarity is usually determined by the effects of aberration and diffraction occurring in the optical imaging system, in addition to the distortions that may occur during the recording of the signal, as well as the nature of the sensor and the time of exposure to the signal (light). And the speed of its response], which affects the brightness of the image and the sharpness of its contrasts.

The concept of mock tissue and its analysis is of particular importance in the field of medical image processing [4] as it is the important visual marker in distinguishing and defining homogeneous areas. Aimed for tissue analysisTo distinguish different areas of the tissues in the image, and to cut these areas into a so-

called Segmentation Based_Texture, where each region is separated from the other, and the incorporation of fractal engineering concepts in the field of digital image processing has solved many problems related to the definition and analysis of the photo tissue [5].

1.1 Processing image digital

There are many treatments that are basic in the science of digital image processing. These processes depend in some way on the frequency diagram of the digital image, as well as methods for improving contrast and brightness in the digital image. Stretching Contrast for images that display in their normal form the values of their elements may represent the full range of the permissible levels of intensity of the image[6]. This can be clearly seen in the frequency diagram for the luminance values in the image, and the withdrawal or extension of the frequency diagram over the total permissible range is represented by the equations below

$$I(\mathrm{x},\mathrm{y}) = 255\frac{I(\mathrm{x},\mathrm{y})}{min + max} \qquad (1)$$

It also provides fractal geometry through mathematical iterations for the purpose of obtaining rich graphic imagesIt can be performed by a computer in addition to the feature of drawing the contrast in the medical images of the features that characterize fractals. Figure (1) illustrates an example of random fractal images [7].

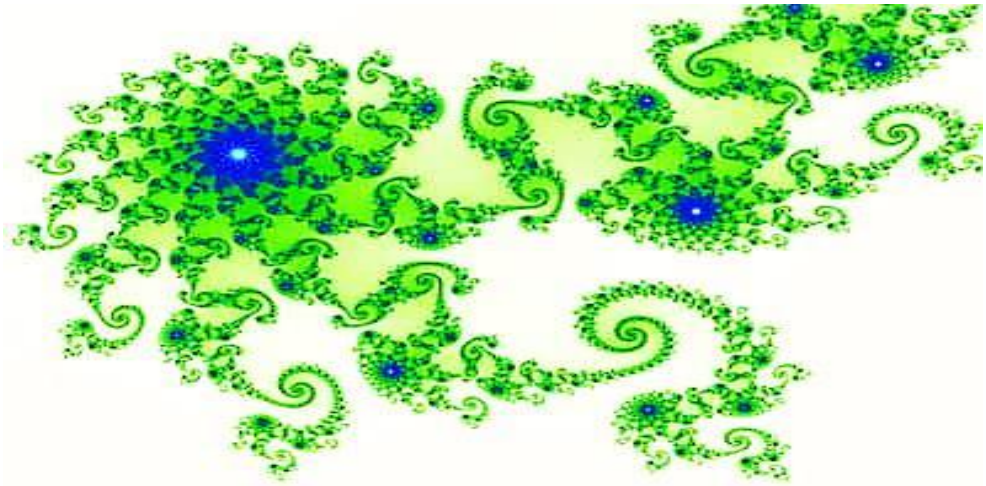


Figure 1. Example of random fractal images

Spread on the image to increase the clarity of the desired details (features) in the image whereThe human visual sensing system has a specific ability to detect and distinguish small variations in the intensity or color of the elements Homogeneous areas these changes will be difficult to sense, which is why most contrast enhancement techniques work to enlargeLocalized contrast in the intensity and color of the image, one of the side effects of this process is to increase the sharpness of the image, which leads to it [8].

This increases the intensity of the noise, which will increase with the increase in contrastIn practice, high-contrast images will have large variations in intensity or color between different objects in the image, so it is visually easy to determine the boundaries of the object and identify the distinctive features in the objects. The images with poor contrast will have gradient heterogeneities and are difficult to detect visually[9]. Therefore, methods of improving contrast will enlarge the variations in intensity or color in the image, which increases the clarity of details in itThe essential stages in the field of advanced image handling incorporate the accompanying regions [10]:

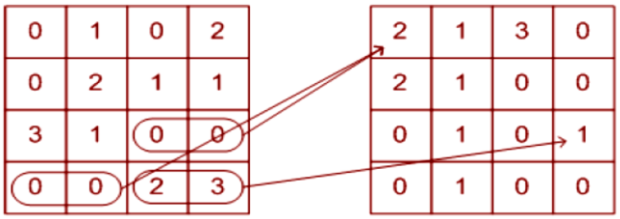
1. Image compression.
2. Image Segmentation.
3. Threshold.
4. Image Restoration.
5. Image enhancement.

1.2 Gray-level co-occurrence matrices (GLCM)

A co-occurrence matrix or a concurrent dispersion is a matrix or conveyance that is characterized on a image as an appropriation of synchronous qualities at a given uprooting [11].Offset (, x, Δy), such as

$$C\Delta x, \Delta y(i,j) \sum_{p=1}^{n} \sum_{q=1}^{m} \begin{cases} 1 \\ 0 \end{cases} if I(p,q) = i \; and \; I(p+\Delta x, q+\Delta y) = j \; ^2 \qquad (2)$$

Pij = Element I, j of the standardized even GLCM. N = Number of dark levels in the image as indicated by number of levels in under quantization on the GLCM. μ = The GLCM mean, determined as[12] as displayed in Figure (2):



(a) (b)

Figure 2. (a) Original images 4×4; (b) the Gray-Level Co-Occurrence Matrices (GLCM)

1.3 An algorithm for calculating variance

This algorithm relies on the image in the edge regions only, as shown in the equation below

$$C = \mu_0/\mu_b \qquad (3)$$

Where C is the local constract.

μo is the average detail of the image.

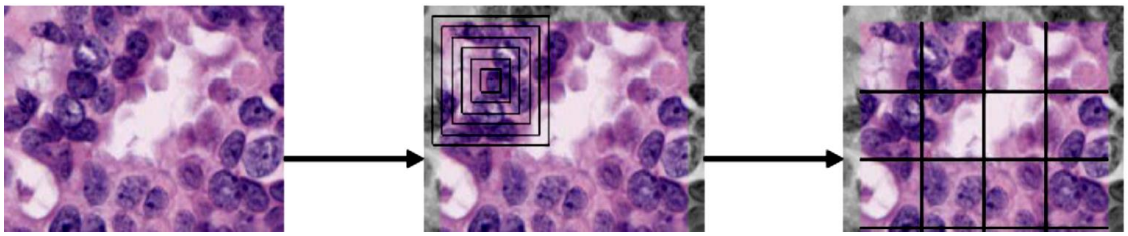
μb is the background rate in the image.

As for the steps of this technology[13], they are represented by the following: -

1- Inputs: - An image whose variance is to be calculated.

2 - Apply the hollder filter effect to get the image edge matrix (Edg)as showm in figure (3) .

3 - calculation of variance.



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

Figure 3. (a) Original image; (b) appٮlied holder filter; (c) applied box counting

1.4 Lacunarity

The word "lacuna" is derived from the word lake in the literal sense of the word which refers to a gap or cluster. In neuroscience, where there are overlapping ramifications as they appear in the "visual tissue" of images, which he defined as the degree of attractiveness, heterogeneity, translation and rotational stability in the image Figure (4) illustrates the meaning of the lacunarity in the images with increasing detail and uniformity mostly, Lacunaritys of volume, little rotational disparity, and high lacunarity means heterogeneity, or the presence of many lacunaritys of different sizes [14]. The lacunarity can be calculated through the equation below.

$$€ = \frac{\sigma(\lambda)}{\mu(\lambda)^2} \qquad (4)$$

Where € is lacunarity
where σ(λ) is the standard deviation and μ (λ*) the* mean

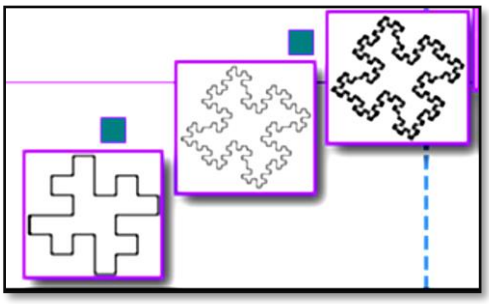


Figure 4. The lacunarity in segment fractal contours

2. Hurst operators

Fractal-based techniques have been used to differentiate the two-dimensional texture patterns for image applications where the fractional dimension is estimated to measure the anomaly of the 2D images, and can portray the surface examples of segmentation[15]. There are different methods for deciding the partial element of 2D images, which incorporate square tallying and Hurst factor calculation strategy One of the significant strategies that have been utilized in different hash applications is Hurst's factor calculation procedure. Since we are managing 3D volumetric information, 2D Hurst administrators have been stretched out to Hurst 3D administrators. As well as expanding the two-dimensional round channels to the three-dimensional circular channels. This expansion empowers design components to be separated straightforwardly from 3D volumetric information without cutting into different 2D images. Since the round channel should have the option to change its breadth size to oblige the dissected volumetric information, a reenactment program was carried out.

In Figure 5, the round channel is cut into 5 roundabout channels for accommodation. In sequential order names assign classes that have a similar separation from the focal voxel. Utilizing the circular channel, a rundown of the greatest contrasts of the dark plane is determined for every pixel distance class. When the rundown has been determined, then, at that point the log both the distance and the distinction in the dark level are taken to ascertain the line fitting for the most un-square . The incline of the line demonstrates the Hearst coefficient of information .This interaction is rehashed to figure Hearst coefficients for each site in the data[16].

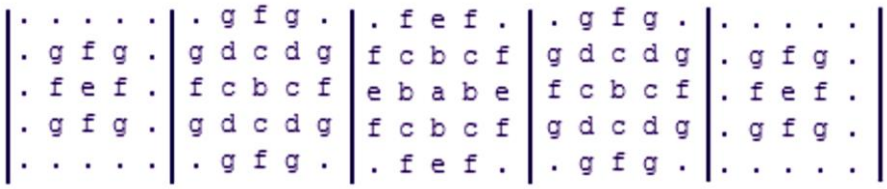


Figure 5. Channel with a 5-voxel wide area and the comparing

2.1 Previous works

1-In 1995 the scientist Yuille relied on improving the performance of digital images using the method of fractal geometry by calculating random functions on the minimum-distance and -nearest neighbor classification[17].

2-In 2002, Gonzales introduced new methods of using multiple filters to smooth out digital images. The research concluded that results were obtained indicating the use of the high pass filter in extracting noise from images[18].

3-In the year 2005 M. Anaya presented the definition of the contours and detection of the edges of digital images using fuzzy logic filters. The results indicated the importance of using the method with digital filters for the purposes of image enhancement [19].

4-urk 2008 presented an improved method using fuzzy logic by extracting noise in digital images and the noise type being linear noise[20].

5-In 2009, Saad presented a method for improving medical images of blood cells and comparing them by using or lacunarity calculations for images, and performing the optimization process for medical images applied in the research [21].

6-In 2012 R. Mehra added chic noise to digital photos and then performed image enhancement and using smart neural networks A neural network was used to change the contrast based on the images where the original image contains different sub-blocks, and depending on those blocks, Details are determined automatically by the neural network. If the pixels of the sub-blocks, the primary benefit of a neural network is to adapt itself from the training data based on the feature area distribution observed in the training phase [22].

7- In 2014, the scientist Biddle reached the dependence of Lyapunov's dimension calculation on the candidate parameters to predict the behavior of the information dimension that is directly evaluated, as the research reached a good quantitative agreement with theoretical expectations. Not only does the understanding of filtering clarify related aspects in calculating fractal dimensions but also produces an indirect but accurate method for assessing Lyapunov's foundations[23].

8- In this paper, Abondghi in 2016 suggested analyzing high-resolution surface (EKG) signal images, and efforts were made to increase the diagnostic sensitivity of the (EKG)by monitoring its high-frequency components[14]. The model was activated using conventional high-frequency filters and comparing its performance with fractal filters[24].

9- Weighing proposal In 2017, the fractal interpolation filter for the first time, using the multi-fractal oscillation analysis (MFDFA), is to obtain the characteristics of the multi-interval gradient if it is concluded that the change in the fractal foundations in the images is large for the negative values of the vertical scaling factor while remaining stable otherwise. A suitable vertical scaling factor can be found to reduce filter effects when one uses a fractal interpolation filter[25].

10- In 2018, Vinegas used a smoothing method using a two-dimensional low-traffic filter, which was a method for evaluating the D dimension. It was applied to utilitarian images of the lung where the technique was applied to three types.Number of images: arbitrary clamor images, and fake fractal images. The images could be prepared utilizing two-dimensional low pass channels to lessen the point and area frequencies. The heterogeneity record, coefficient of variety, was likewise determined for each advanced image [26].

11- In 2020 researcher Pravesh suggested using a half-wavelength band pass filter coupled with half-wavelength from the fractal filter Koch filter to show the effect of the space gap in terms of response and with a central frequency of 2.02 GHz in communications and radar systems where the filters play the role of important elements in the performance and cost of this system in addition to improving and smoothing Digital images improve system performance in general [27].

3. Research procedure

In this research, a number of practical steps were relied on, including reading medical images, determining contrast in images and segmentation operations in medical images, as well as the steps of fractal engineering operations as a required method and an important method in applying all operations to the accuracy of the medical image, and passing the current two-dimensional medical data in the proposed algorithm. .Algorithm has been implemented the proposed work was programmed using Matlab and Microsoft VisualC++ , Figure (6) shows the most important steps that were adopted in the research.

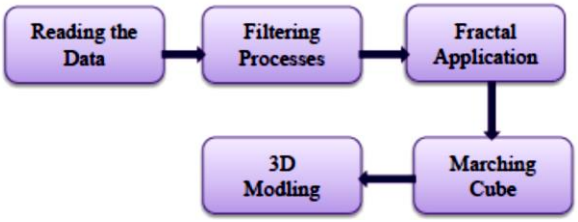


Figure 6. General steps of the program

1-Several images were trained, each containing a hundred images of different sizes. Figure (7) shows a sample of the obtained images where the application of the infected image detection process succeeded, in Figure (7) the image section within the frame was used separately to record the database features for each of them. From medical images, where the database was created to contain (100) training forms

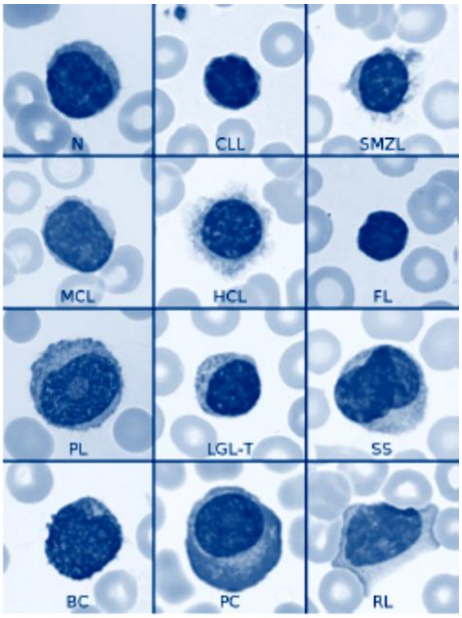


Figure 7. Sample of medical images

2-Texture properties extraction that uses the Matrix Occurrence-Co Level Gray as it describes the spatial relationships between levels of gray in the image. It is these properties from which the contrast properties, correction properties and properties are extracted.The homogeneity and randomness properties are as described previously in Equation. (2). Figure 8 shown program implementation steps

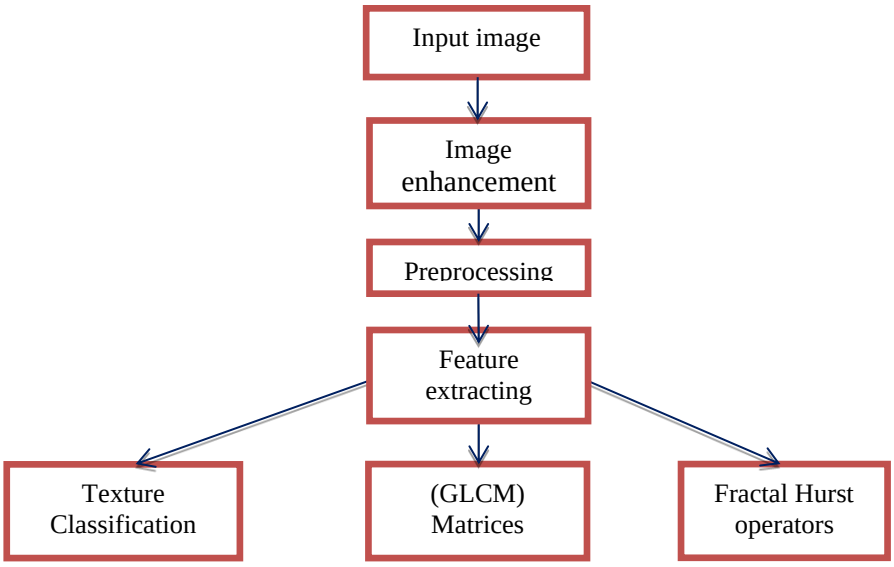


Figure 8. the Program implementation steps

3-The multifractal analysis is the calculation of the fractal of the dimension where the sets of points having the uniqueness factor (α). Where the polyfractal characterizes the image strength spectrum and represents the geometric characteristic of the fractal dimension. It can be presented by plots of the fractional dimension against the value of(α), as shown in Figure (9)shown the muti fractal analysis . And it can be displayed as a continuous function, as shown in Figure (10)

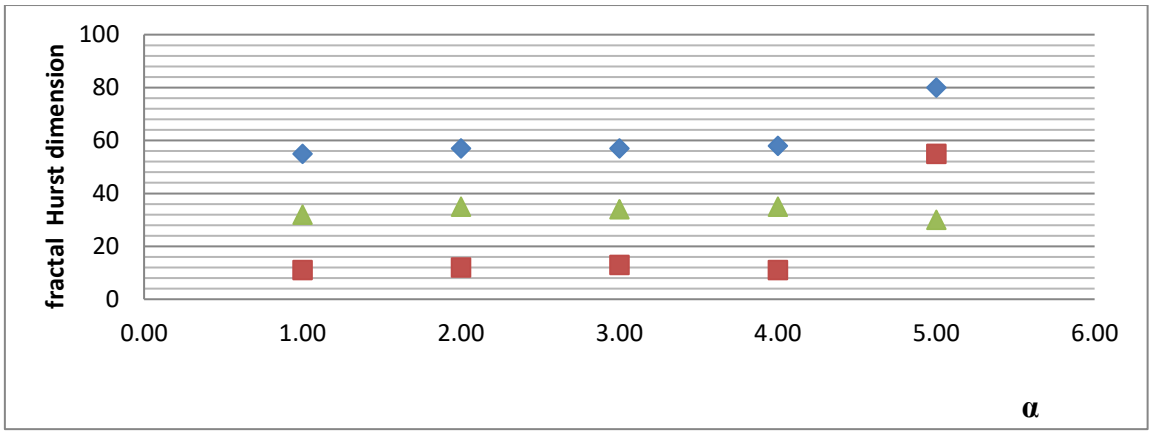


Figure 9. shown the muti fractal analysis

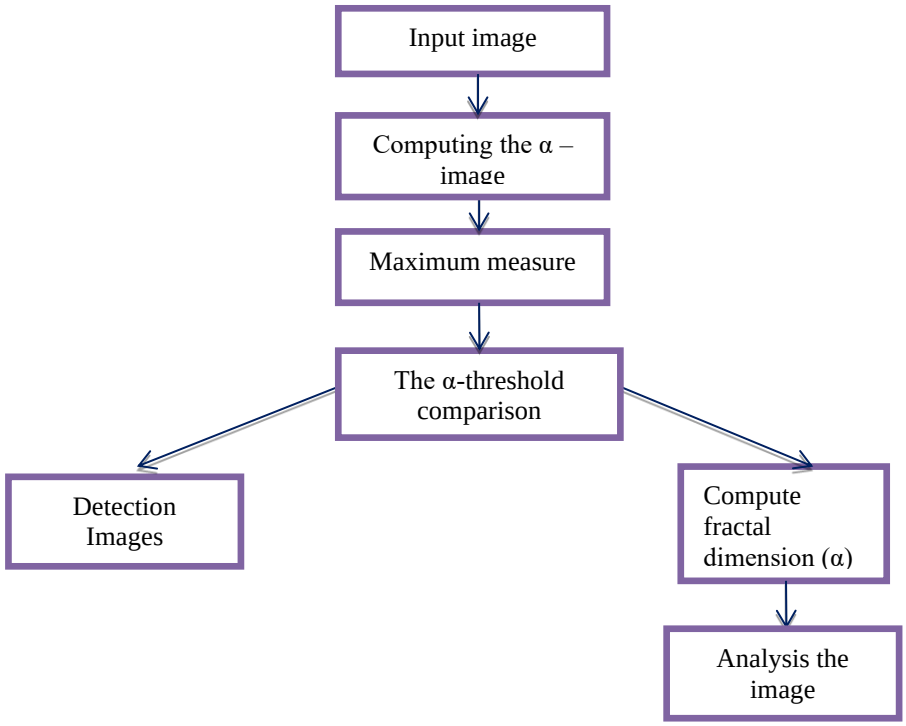


Figure 10. Step of mutifractal method

4. Result and dissection

Experiments and analyzes are performed to assess the presentation of the proposed technique. For each sample, fractal features are extracted using the box count method and features are selected by the fractal where the number of samples is determined and then the performance method is evaluated with varied training and testing. The automatic training and test groups are selected. Classification is applied to 80 samples of the images. With the use of the Vector Machine Classifier (SVM), which is considered a supervised classifier for image data due to its high performance, its ability to deal with large, high-dimensional data sets, and its flexibility in modeling various data sources. By applying Matlab for medical images and then measuring the presentation of models the classifier, and the determined boundaries are:

1. True positives (TP) when the framework accurately orders the subjects as ordinary,
2. False positives (FP) as the framework inaccurately orders the subjects,
3. True negatives (TN) when the framework accurately orders subjects as strange. For general execution,

Rating Ratio (CCR) which gives the level of subjects that are appropriately arranged Table (1) shows in percentage the confusion matrix for each method, which represents the average execution of the SVM classifier for each individual class with an actual class representation of the medical images used.

Table 1. Test results show number of tests of images (100)

Feature extracted method	**Gray-Level Co-Occurrence Matrices (GLCM)**		**Fractal Hurst feature**	
	Normal (1)	Abnormal (0)	Normal (1)	**Abnormal (0)**
Normal (1)	90%	10%	98%	2%
Abnormal (0)	10%	90%	5%	95%

As for the calculation of the execution time, after obtaining the results by applying the methods to the medical images, as in the figure (11), Through the work, it was found that the implementation time for the image resulting from applying a(3 * 3)window took the least time, while the image resulting from a (7 * 7) application took more time.
To study the effectiveness of the proposed system in the treatment of related medical images, we calculate Accuracy within and according to equation

$$class\ accuracy(i) = \frac{number\ of\ correctil\ classified\ imges\ classi\ €}{number\ of\ images\ classi\ €} \quad (4)$$

Figure (12), shows the distribution of accuracy of classification results as percentages over all grades from(5) to (25) using the fractal method. It is noticeable that some classes were the rating is below normal.

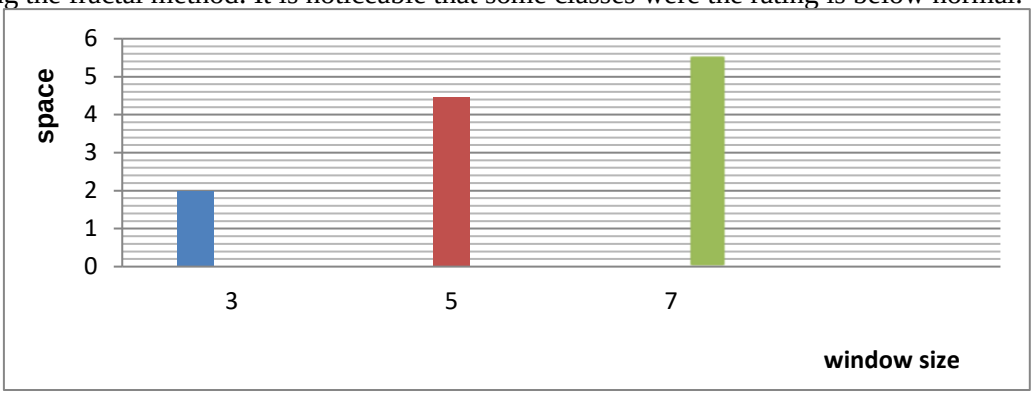


Figure 11. Image resulting from applying a (3 * 3) and (7*7)

2-Figure (12) shows the distribution of the accuracy of the classification results in percentages over the entire rows from(1) to (90) and by using the fractal algorithm of the medical image groups, it is noticeable that some classes had a rating of 100%. The decrease in the extent of severity levels increases with the increase in weakness in the areas of the rims and their poor clarity and less variance appeared in the results of calculating the variance for the different cases.

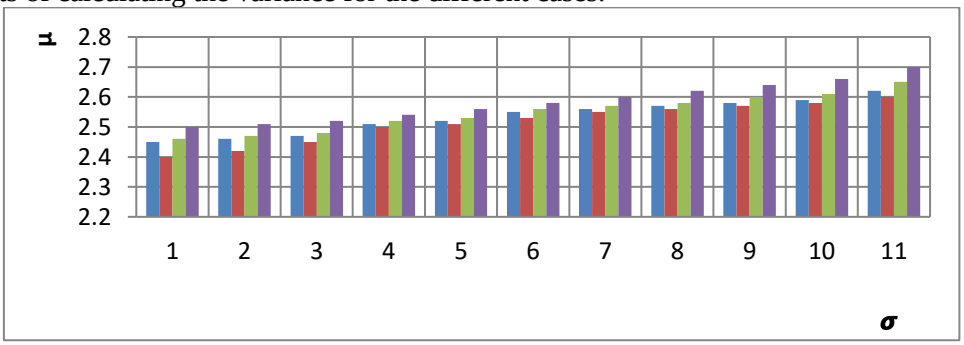


Figure 12. Sample of GLCM Matrix

3-Thresholding Level-Multi techniques were usedIn order to extract the histological image based on the fractal dimension of the image, and Table (2) shows the most important results obtained. Table(3) shows correlation and variance where the contrast for the three-color coefficients is small when the correlation value is high, in such a case larger blocks can be obtained. The data entered was analyzed, and the value of the gap was calculated, where the value of the uninfected medical images showed that the value was close to one, depending on the level of analysis and the accuracy of the data to be extracted from the image.

Table 2. Important results obtained the fractal, lacuanarty and GLCM Features

Medical images	**Fractal dimension**	**lacuanarty**	**GLCM Features**			
			Constraction		**Energy**	
Sample 1	1.892	1	1.345	1.987	0.002	0.003
Sample 2	1.213	**0.9**	1.123	1.245	0.003	0.005

Table 3. Correlation and variance where the contrast for the three-color

Color Space	**Covariance**			**Variance**
	R	**G**	**B**	
R	1.0	0.982	0.972	**36**.33
G	0.982	1.0	0.992	**32**.45
B	0.972	0.992	1.0	30.67

From the above tables, the following can be deduced:

1. The fractal geometry is flexible as it is improved and the possibility of generalization. It also has a greater generalizability than traditional optimization methods. The method can be extended to a wider range of improvement. The results confirmed that the algorithm should be applied using window dimensions(7, 5, 3)at least to obtain accurate multiple fractal coefficients for the medical images .
2. Computational complexity: the details and edges can be controlled using the fractal method
3. Accuracy: Despite the convergence of results (GLCM Features) with fractals in repeated experiments, however, extracting an approximate image can lead to a sketch of the image boundaries of the affected subjects and thus significantly speed up the treatment planning process. Figure (13) shows the accuracy percentage.

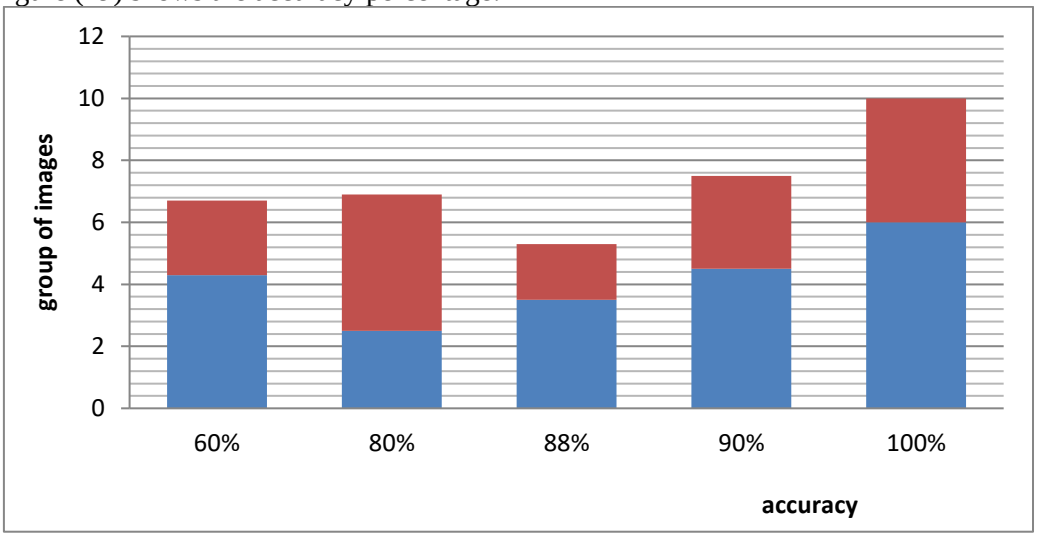
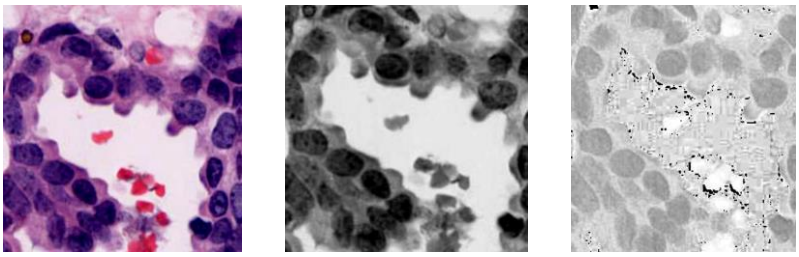


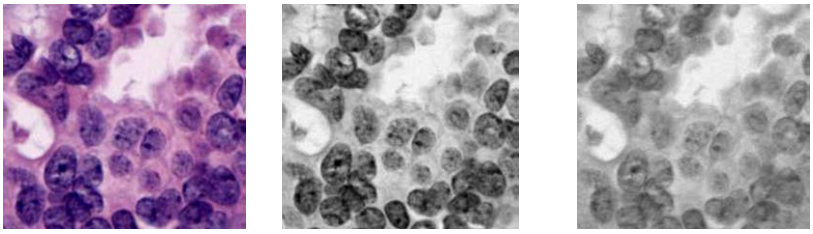
Figure 13. Accuracy percentage of medical images

In this proposed method, the number of iterations (repeat number) and standard deviation (STD) were determined for the gray intensity values in the marginal regions of the medical images and for different cases, and as shown in Fig. (14),and figure (15) where a gradual decrease in the STD values was observed such as Increased smoothing times for all cases in the images when using different smoothing windows. The magnitude of the decrease in STD values increases with increasing kinematic range of gray intensity levels in the edge region. Figure (16) and Figure (17).



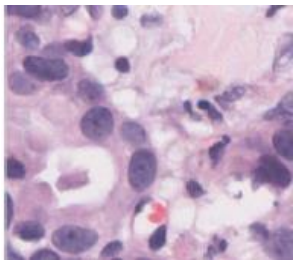
(a) (b) (c)

Figure 14. (a) Sample of original images, (b) Hurst filter, (c) edge detection



(a) (b) (c)

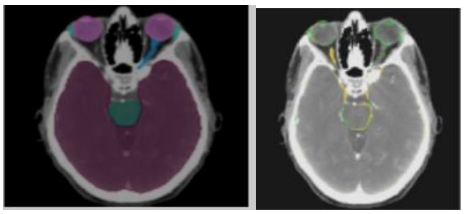
Figure 15. (a) Sample of original images, (b) images with multifractal techniques, (c) edge detection



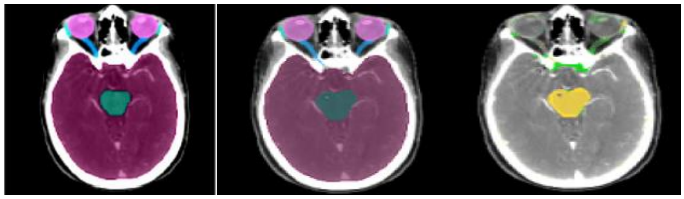
(a)

(b) (c)

Figure 16. (a) The disintegrated image, (b) picture after edge recognition utilizing thresholding, and (c) in the wake of eliminating extra detached pixels



(a) (b)



(c) (d) (e)

Figure 17. The disintegrated image, (b) picture after edge discovery utilizing thresholding, and (c) subsequent to eliminating extra detached pixels, (d)applied hurst channel, (e)hurst channel with thersholding (4.5)

Figure (18) presents a sample of the resulting lacunarity curves belonging to the same medical images in the discrimination process. It is evident that the difference in the details of the images used leads to an increase in the lacunarity value and thus a shift in the lacunarity curve to the higher values of the amount (1)

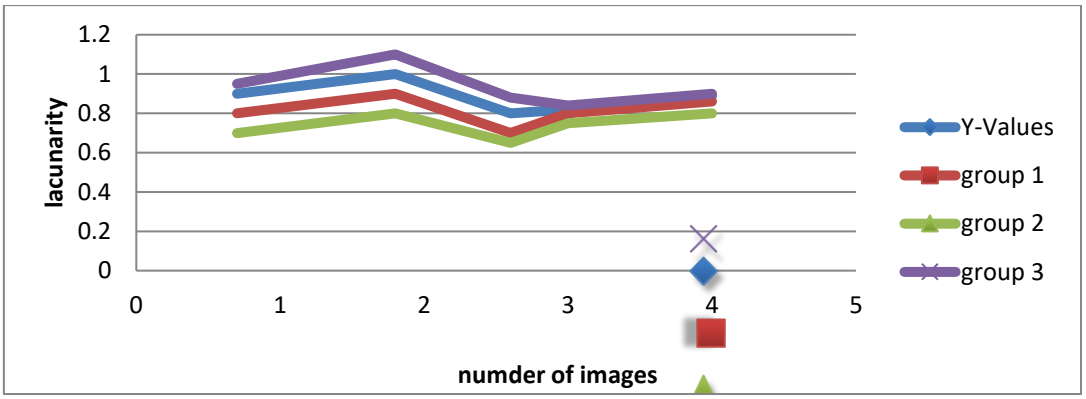


Figure 18. Sample of the resulting lacunarity curves

Features can be extracted on the basis of the fractal dimension through differences in density and the complexity of the texture in the whole image and classified according to the three groups, which were by (4) and according to what is shown in Figure (19) and to estimate the correct classification rates. The results showed that 97.2% and 97.7%and 98% of the three groups could be achieved in the medical images used, and for the pathological conditions in the images. It is extracted from several filters.

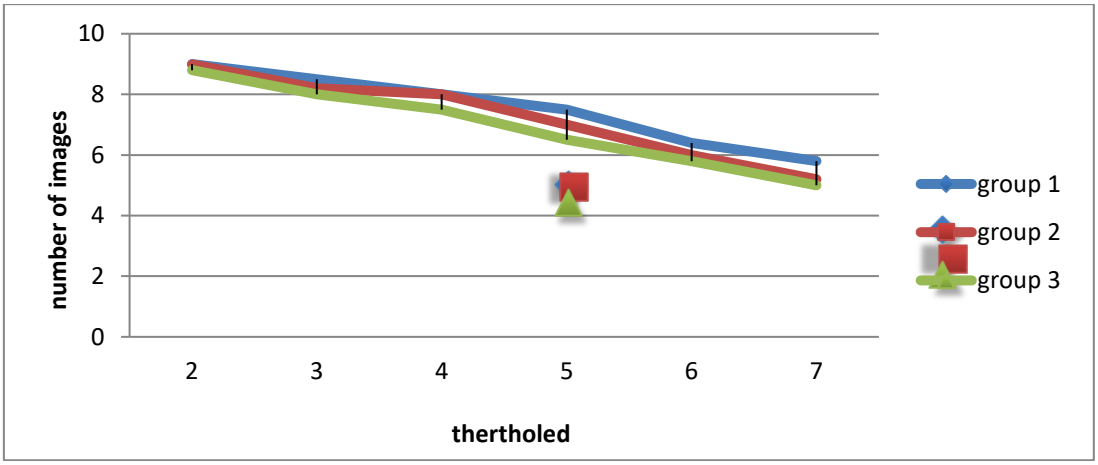


Figure 19. Correct classification rates estimate

5. Conclusion

Depending on the findings of the research, a set of recommendations can be concluded

1-The details of the image in the regular method were clear, but there was a loss of some colors, and as for the proposed method (hurst fractal), it gave good results for all images, and as can be seen from the resulting images and from the distribution of the resulting colors after the contrast improvement process that the proposed method preserved the original colors of the images and no loss occurred. In some colors for medical images.

2- The noise levels that can appear in medical images are minimized by using the fractal filter.

3- With drawal of variance leads to more accuracy in forming blocks of code and saving processing. Time and the least amount of time possible for the data processed.

4- Fractal coding increases the importance of image data with very little distraction

5- The experimental results showed the effectiveness and potential of this approach for different colored medical image in database manipulation applications while maintaining image quality.

6- Image data can be managed using the proposed method in the future with the use of the genetic algorithm.

7- Further research is working on a greater number of fractal features in order to perform optimization and final classification of medical images.

8- Work to improve the implementation time of the proposed method programmatically to suit the actual medical work.

9- Fuzzy logic concepts can be used as one of the modern techniques utilized in image preparing and clamor expulsion from clinical images.

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