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A Survey on Applications of Fractal Dimension upon Various Image Processing Applications

Sumitra Kisan[1], Sarojananda Mishra[2], Sasmita Mishra[3]

Dept of Computer Science & Engineering, VSSUT Burla, Odisha, India[1]

Dept of Computer Science & Engineering, IGIT Sarang, Odisha, India[2, 3]

Abstract: Image processing is the analysis and manipulation of a digitized image, especially in order to improve its quality. It is very necessary in case of medical science and other marine images to process the image to improve the quality of research. There are several techniques in this area to process this type of images. Fractal Dimension Calculation is one of the very popular and updated topics in this field to process various images. In fractal geometry, a fractal dimension is a ratio providing a statistical index of complexity comparing how detail in a pattern changes with the scale at which it is measured. In this review article we have provided a detail application of fractal dimension and fractal geometry in the field of various type of image processing like marine images, brain images, human body images etc. We have also provided a 2D image processed by fractal geometry.

Keywords: Fractal, Image Processing, fractal geometry

I. INTRODUCTION

The fractal concept is being originated from the term "fractal" from the Latin "fractus". It is a very useful tool for observations of large variety of naturally occurring phenomena. A fractal is the irregular geometric object with the infinite nesting of structures about all the scales. These Fractal objects are found everywhere in nature, like coastlines, fern trees, snowflakes, clouds, mountains, and bacteria. The most important properties of these fractals we can easily observe that the self-similarities. Fractals are very self-similar, which can be told that structures may be repeated at many different scales of size. The fractal dimension gives a quantitative measure of self-similarity and scaling. There are a large number of fractal geometry applications that are being developed and studied in the past and still there are a lot of researches that are being going on in all over the Globe. One of the best applications of Fractal Geometry is in the processing of brain magnetic-response (MR) images. For tumor detection, there are the existing fractal-based techniques and they have also proposed three more modified algorithms using fractal analysis.

For every method, they have divided the brain MR images in to several numbers of pieces. They have applied three methods like PTBC (piecewise threshold box counting), PMBC(piecewise modified box counting), PTPSA(piecewise triangular prism surface area). The first PTBC method Contains thresholding the pixel intensity values. For the next two methods the intensity is being used as the third dimension. But the PMBC and PTPSA methods are mostly suitable for locating the brain MR images [1]. This Paper is organized as follows. The Section II Provides a study of applications of Fractal dimension in the field of medical related images, and in section III it provides a study of fractal dimension upon marine and other defense related image. In section IV we have provided a processing of a 2D image through fractal dimension. Finally the paper concludes in Section V with conclusion and future work.

II. FRACTAL APPLICATIONS IN MEDICAL SCIENCE IMAGES

The Fractal concept is very popular in the field of image processing in the last decades which is being applied to various fields especially in medical science images. One of the best application of fractal dimension in medicine is modeling of tissues and other organs, analysis and interpretation of different types of images. Medical images are generally very complex in nature. These are irregular and noisy in shape and size. So in this regard the diagnosis and result is depend upon the analysis of the texture.
The intention of fractal applications upon medical science is to apply fractal-based algorithms and new and improved techniques of these algorithms to identify various problems in human body by observing the images and identifying tumors in brain magnetic-response (MR) images etc. Various researches have been applied on fractal geometry in different angles of image analysis and also for pattern recognition. If we consider the Magnetic-resonance images these are typically have a degree of noise with randomness that is associated with natural random structure. But fractal analysis is appropriate for these magnetic response images of brain [1].

There are various methods for calculating fractal dimension that is Reticular cell counting method, Keller's approach, Differential Box counting method. Fractal dimension D in a set A from properties of self similarity can be defined as

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$$D = \log(N) / \log(1/r)$$

Here, N is the number of distinct copies similar to A. Similarly A is scaled down by a ratio 1/r [2].

The breathing dysfunctions are generally observed in interstitial lung diseases. From various pathological conditions these can be characterized by progressive alteration of the lung parenchyma. Taking in to considerations of over 150 disorders of the lung parenchyma, these underlying factors with its mechanisms of the processes of the diseases vary from one ailment to another. The total diagnosis of these pathologies are created based on the overall history of the patient, various physical examination, several laboratory tests, and pulmonary function testing with visual findings on chest X-ray images. In [3] they have provided various digital image processing techniques to extract quantitative information from regions of interest (ROIs) that are obtained from high-resolution computed tomography (HRCT) images. They have applied design feature vectors for the classification of the images with six radiographic patterns that are being associated with diffuse pulmonary diseases (DPDs). In this they have applied methodologies like image acquisition, preprocessing and ROI Extraction which is being conducted with a database containing 247 HRCT images which are selected by a group of radiologists. The images that are related to medical science like images various cancer images, various irregularities in human health and other living organisms are generally rough in nature. These images can be quantified by fractal dimension D. If we consider these medical images diagnostically, very clear and important characteristics and information can be obtained from their images. In[4] they have described the fractal dimension of Dental Radiographic images of irregular regions of interest. According to this near boundary in different tissues and structure the fractal dimension is being changed clearly. Medical related images can be considered as intensity in every pixel. The Gray level calculates the intensity in case of radiological, magnetic and ultrasonic images. These ranges of fractal dimension are in between 2 and 3 upon various surfaces. In this research they have applied three techniques like rectangular prism surface area method, triangular prism surface area method, and intensity difference scaling method. Considering four regions from a dental radiographic image the Fractal dimension D, Number of scales, Number of pixel pairs is being calculated. Face shape detection and classification is one of the important requirements for medical science. Many researchers working upon this and several issues are being developed in this regard. This is very popular in case of plastic surgery and other DNA-RNA matching applications. In[6] they have discussed about face shape classification. They have applied three techniques like facial region similarity, correlation and fractal dimensions. A human face can be classified upon several parameter like shape, color and gesture. This classification will be helpful detecting criminal, detecting other peoples associated with fraudulent activities. They classified and compared the face with different geometrical shape like ellipse, rectangular, triangular, oval etc. The testing of the face shape classification is designed using three types face datasets like Caltech with 450 faces, Cuhk with 260 faces and Lfw with 200 faces. The fractal dimension of the object is calculated as

$$D = \lim_{\varepsilon \to 0} \frac{\log N(\varepsilon)}{\log\left(\frac{1}{\varepsilon}\right)} \quad \ldots\ldots (1)$$

According to N.K. Bansode[6] at. all. the result according to Eq. (1) compares the face with all geometric values and minimum similarity represents the approximate shape of the face.

In the last decades fractal and multi fractal dimension applications are extremely applied in many medical signals. These applied in various fields like segmentation, texture analysis, pattern recognition etc. In[5] they have provides the different applications of these fractal techniques and algorithms in various medical signal analysis. These biological signals are generally non-stationary. So the images of ECG or EEG need some special attention. The biological signals generally depend upon high complexity of the system and their acceptance to various environmental factors. So these images need some special security and attention for processing by using different type of image processing techniques.

III. FRACTAL GEOMETRY UPUN OTHER IMAGE APPLICATIONS

Fractal Geometry applications are the revolutionized and upgraded technologies for processing of various images in the recent image processing research. There are a huge amount of images starting from day to day life to the medical and defense applications which needs proper processing to find out different problems to for various applications. In remote sensing applications the natural surface study and analysis is managed by fractal geometry. Fractal Geometry is very much useful in remote sensing applications. In[7] they have applied synthesized fractal surfaces to a reliable and controllable use within remote sensing applications. They have consider the physical criteria to calculate the minimum number of tones of the weierstrass-mandelbrot(WM) function require for properly synthesize realizations of fractal Brownian motion. A WM is the superposition of infinite sinusoidal tones and the periods are formulated in wave number domain with geometric progression which is functioned by an irrational number. The main approach is to determine how effectively the generic remote-sensing problem, the WM can be seen [7]. Fractal analysis can be applied to the images of photochemical lignin polymer captured by the use of tunnel microscopic scanning. In[8] They have provides the analysis result of the regularity of lignin type polimer at different levels of organizations. They have provided that at 95% confidence level there is no such

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difference in fractal dimension between the images presented at different organizational levels of photo chemical lignin. It means the lignin produced in vitro conditions with photochemical technique of synthesis, has a fractal structure. Finally the captured values of fractal dimension is in better agreement for the theoretically predicted value of the poly addition and poly condensation technique of polymerization, which are also known as bulk model.

Soft Computing Techniques are now the most popular computing techniques for various problems. Starting from a modern toy to a human body soft computing technique is applied everywhere for study the behavior and to behave like a metaphor of the system. Artificial Neural Network is one of the most popular topics in the field of soft computing in the field of computer science. Artificial neural network is a combination of Artificial Neurons made up of interconnecting neuron which may work for the generalization or to organize data. The general task of a neural network is to produce an output pattern when a particular input pattern is available [9]. In [10] Y.C. Tzeng et al. descried about the application of fractal in Radar target detection. They have applied DLNN(Dynamic Learning Neural Network) for the reconstruction of clutter dynamic model. Further more for computational problems purpose they have used fractal dimension to distinguish the chaotic behavior of the clutter's geometric aspects.

They have applied differential box counting method for the calculation of images fractal dimension. Their ultimate technique uses DLNN with Fractal Dimension for the detection of various clutter paths. For real time experiment purpose they have applied SAR(Synthetic Aperture Radar) image data set. Four images have been taken as experimental purpose. False alarm level is being set to 0.2. They have also provides a comparison of conventional constant false alarm rate (CFAR) algorithm and DLNN.

The iris is used as authentication for various personal. This iris contains the textural contents and information which is extracted using various approaches like Gabor Filter, Wavelets etc. In[11] they have discussed about extraction of fractal dimension for Iris images. In case of Box counting method the Iris image is first preprocessed initially and then it divided into several blocks. But in this study they have applied fractal dimension techniques for this Iris images. In this paper they have taken CASIA IRIS V3 Interval images. They have taken five images, out of which three images were used for training and rest two for testing purpose. They have applied 3D DBC method for this purpose in which the images were first divided into rectangular iris strips. Then these are divided into blocks. The classification is being performed using Bayesian and SVM classifier.
The dimensionality was 60 for fractal dimensions calculated based on effective information based feature and Hanman Transform. Topothesy and 2-D DBC had a dimensionality of 270 and 28 respectively [11].

IV. PROCESSING OF A 2D IMAGE BY FRACTAL DIMENSION

Fractal dimension calculation can be done on any 2D image. For an experimental purpose we have done fractal dimension calculation of an colour image. Figure 1 shows the fractal dimension of the colour image. In Gray scale colour mapping it provides the fractals in this image. . Fractals are generally very self-similar, which can be told that structures may be repeated at many different scales of size.

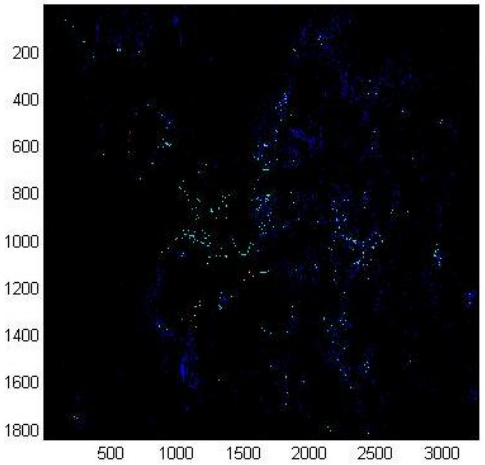

Fig.1 Fractal dimension of a 2D color image

Every fractal contains a numeric fractal dimension and this can be used for indicating how the complexity of the fractal. In this figure it shows the two dimensional view of the fractal which provides a particular numerical value for a particular point. In X-axis the value contains starting from 500 to 3000 where in Y-axis it contains from 1800 to 200. So in this manner mathematically a point can be representing in terms of two values representing two axes respectively.

Fractal dimension calculation has a huge application in the image processing field. After fractal dimension calculation there are several techniques that can be measured to calculate the area of the region, area of a state or area of a country. 2D, 3D box counting method is one of the very popular techniques that can be applied in this field to calculate the area of a region using image processing. The box counting method for gathering information and data is basically analyzing complex objects and patterns into smaller pieces which may be called as boxes. There are several scanning techniques that are being used to scan the boxes in different angle. Fixed grid scans, sliding box scan, these are the various scanning techniques for scanning the images in order to process the images. If N(r) is the number of boxes of side length r required to cover the set then the box counting dimension can be defined as

$$\text{Dimension}_{box}(S) = \lim_{r \to 0} \frac{\log N(r)}{\log\left(\frac{1}{r}\right)}$$

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The box counting algorithm counts the number N(r) for different values of r and plot the log of the Number N(r) versus the log of the actual box size. The advantages of box counting are that maximum cases N(r) can be easily calculated and the boxes covering and packing numbers are generally equal.

Fractal dimension is very useful but so many cases we have to careful because we should not consider the only numbers because in case of calculating fractal dimension of a tree we are just analyzing the image not the actual tree. From an image we are processing the image in the computer through different algorithm. So if we consider a real tree than the fractal dimension may be somewhere between two and three, but if we are analyzing the image of a tree than the dimension is in between one and two. One should be careful at the time of converting color image to gray or black and white image because it may affect the fractal dimension. The small number of boxes provides more accuracy than that of larger boxes. The calculation of fractal dimension of images with arbitrary size M x N (where M is not equal to N) is also required more attention for fractal dimension calculation as well as applying box counting method also. In order to improve the estimate accuracy, it is required obtain the smallest number of boxes to completely cover the image intensity surface at each specific box dimension. In [19] they approach three techniques for this problems the first one is about the box height selection that provides a finer measure, the second lies in the determination of the number of boxes that guarantees the least number of boxes can be obtained to cover every block for each specific scale; and the third one is about completely covering the image intensity surface using overlapping blocks without violating the basic requirements of box-counting dimension estimation.

V. CONCLUSION AND FUTURE WORK

The Fractal Dimension Calculation and fractal geometry is one of the most popular and widely used topics for Image processing. The fractal dimension calculation along with box counting method is discussed in this paper. There are several types of images in this world which needs to be processed for better result and for better experiment on different purpose. This paper provides a brief review of fractal dimension calculation upon various images that are being developed till date. For an experimental purpose we have calculated the fractal dimension of a 2D image using fractal dimension calculation technique. The box counting method and differential box counting method is also very important for the fractal dimension calculation of an image. In next research we will apply fractal dimension calculation as well as differential box counting method for processing of various color image and gray scale image with their comparison in their pixel and other parameters. These models may helpful for different image processing as well as it will provide a better and upgraded technique for various color images.

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