Fractals Study and Its Application

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***Abstract*—The overall of this paper is a review of fractal in many areas of application. The review exposes fractal definition, analysis, and its application. Most applications discussed are based on analysis from geometric and image processing studies. Patterns of some fractals will be discussed. Some simulation results are supplied to illustrate the discussion. Simulation resulted are from various software and tools. Some principles of fractals with informative patterns have been simulated. Whereas the simulations could support some recommendations for prospective purposes and applications. The prospective application may help in predictive pattern of many fields. The predictive pattern will lead to pattern control and pattern disruptions.**

***Index Terms*—fractal pattern; predictive geometric; inverse fractal; segmentation; simulation images**

I. Introduction

A fractal is a fragmented geometric and no-equation represented shape but it has the same degree of non-regularity on all scales. As no equation representation, subdividing parts from a whole object into reduced-size copies would be used to describe the object. Fractals are generally self-similar, independent of scale and never-ending patterns. These fractal patterns are capable to describe many real-world objects that do not correspond to simple geometric shapes or any shapes having definitely clear equation patterns. Some objects may have clear pattern but they are able to self-similar construct with indefinite iteration, such as bee hives, ferns, clouds, mountains, turbulence, and coastlines.

From very basic mathematics and physics, this paper will discuss fractal from two variables *length* and *angle*. These two variables are a concept of scalar and vector topics. However, we introduce parameter of balancing parameter. The balancing parameter is a numeric of binary or two or pairs, which was inspired from Islamic holy book, Al-Quran.

II. Fractal Analysis

A. Balancing Parameter - Pairs

A pattern of pairing and we name it as a balancing parameter is the focus of this study. We are inspired with the balancing parameter as mentioned in Quran wherein earth, mountains, rivers, all kinds fruits were created in pairs [1]. Moreover, the fractal can be found in nature. Any user of Google Earth can explore worldwide satellite imagery and terrain for many places and discover natural fractals such as mountains, rivers and coastlines shows a special collection of natural fractals on the Earth [2]

Tropical fruits were characterized using fractal analysis of texture and contour analysis [3]. Pineapple and *durian* were able to be analysed based on their texture and contour analysis. Another research, the border image and fractal dimension were computed and used to classify the fruit and vegetable [4]. The fractal dimension was computed using box counting technique and these dimension values are used as the classification features.

It is said to be a pair when two numbers or objects linked in some way, the pair x and y is denoted (x, y). An example of pair may be identified by [5]. An existence of a pairing hierarchy is confirmed in *iron-selenide (FeSe)*. Another roles of pairing can be found in [6] in which *lincRNAs* can be identified in *Arabidopsis* with potential in regulating target gene expression in trans by both RNA:RNA and RNA:DNA base pairing.

The pairing parameter must be the main feature of any fractal to be balanced. We know many terms of pairing parameters in many fields. Binary systems use 0 and 1, electrical circuits use ON and OFF, human senses use LEFT and RIGHT, HIGH and LOW, OPEN and CLOSE. In trading we use SELL and BUY, CALL and PUT option, BEARISH and BULLISH graphs. However, we must highlight THIRD option. This third option will determine the dimension and how far any self-similarity iteration will go. This option is identified with many terms but the same feature. They are NEUTRAL, COORDINATION, STRAIGHT but will effect to balanced state in static view or harmonious condition in dynamic view.

B. Fractal Dimension

A basis for modelling in nature could be constructed with fractal geometry [7]. A basic geometry feature is dimension. But the dimension in fractal is different concept from the dimension in spatial geometry as the dimension in fractal relates to a magnifying factor due to iteration.

Mathematically, fractal dimension (D) can be calculated with the following equation 1:

$$D = \frac{\log(N)}{\log(r)} \tag{1}$$

where N is the number of boxes that covered the area and r is the magnification or the inverse of the box size. Fractal dimensions tell the static geometry of an object. Fractal dimensions tell the static geometry of an object. An example of fractal dimension is the Hausdorff-Besicovich Dimension [9], [10].

Fractal methods could be used in iterated function systems (IFS) [8]. IFS with their variations describe an object as geometric representation of detail for computer graphics and computer aided geometric-design. However, fractal design and modelling of existing geometry remains puzzle-unexplored, and poses the critical inverse problem.**The inverse problem is how to identify a pattern of the existing shape.** Therefore, the iterated function systems should become practical and help in identifying any patterns from the existing fractal in nature.

Peng et. al. [11] applied fractal analysis to human physiology. They defined fractal dynamics, posed some special problems of physiological time series. The analysis of the output is from two model systems: (1) the system under involuntary (neuroautonomic) control, *i.e.* human heartbeat regulation; and (2) the central nervous system with the voluntary control *i.e.* human gait regulation. The outputs of these two systems are focused on health and disease analysis.

Fractal dimension was used to characterize data texture in physical and biological sciences. Aparecido Nilceu Marana, *et. al.* [12] used density estimation based on Minkowski fractal dimension. The important problem of crowd monitoring is an estimation number of people in an area under surveillance. When an area reaches an occupancy level greater than the designed one, people safety can be in danger. The results of their experiments demonstrate that fractal dimension can also be used to measure levels of people congestion in images of crowds. With a statistical and a spectral technique, about 300 images of a specific congested area of people were tested.

L. da F. Costa, *et. al.* [13] have assessed the efficacy of texture measures for estimating levels of crowd densities in image. A set of nearly 300 real images capture from Liverpool Street Train Station, London. UK were assessed using texture measures extracted from the images through four different methods. They are the methods of Fourier analysis, fractal dimension, gray level dependence matrices, and straight line segments. The estimations of crowd densities are given in terms of the classification of the input images in five classes of densities from very low to very high). Three types of classifiers are used: an approach based on fitting functions, Bayesian, and neural. They concluded that texture analysis is very effective for the problem of crowd density estimation.

Plotze Rodrigo d.O, *et. al.* [14] proposed a method for the extraction of morphometric characteristics of plant leaf structures. A sample of 10 species of the genus Passiflora was used in an experiment to test the method. A wide range of leaf forms was seen in the genus but some species pairs or groups having morphological similar and makes identification difficult. To generate complexity measures of their internal (veins) and external (leaf outline) form, the multiscale function of the Minkowski fractal dimension was applied to digital images of leaves. Since no leaf was erroneously identified the measurement was very accurate in correctly differentiating species. In the method of recognition and classification procedure, a small number of leaves per species were sufficient for establishing a characteristic pattern for each of them.

A route to fractal assembly using tiles based on DNA parallelograms were discussed by Alessandra Carbone *et.al.* [15], [16]. A major challenge for nanotechnology is how to generate fractal structures by self-assembly. The specificity of motifs has previously led to a protocol that appears likely to be capable of producing fractal constructions. To produce the fractal structure, a protocol depends on gluing the set of tiles with special glue tiles. DNA sticky-ended interactions and the well-behaved structural nature of DNA parallelogram have capability to produce that fractal construction.

III. SIMULATION RESULTS

Here, we are presenting some of the significant results that were produced using MATLAB. This is based on Michael F. Barnsleys simulation the game of chaos. The result is the Sierpinski triangle. The simulations are shown with various STEPS. The STEPS is the number of iterations and therefore the number of points in the resulting image. Clearly form the first two STEPS, we could **identify a pattern of the existing shape with segmentation method** Figure 1.

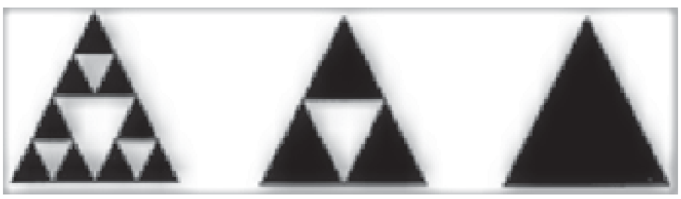

Fig. 1. The Sierpinski triangle STEPS 2, 1 and SEED

The following figures are simulation results with STEPS 100, 1000, and 10 000 respectively, Figure 2, 3, 4. Hypothetically, STEPS or iteration may represent **density or age** of fractals.

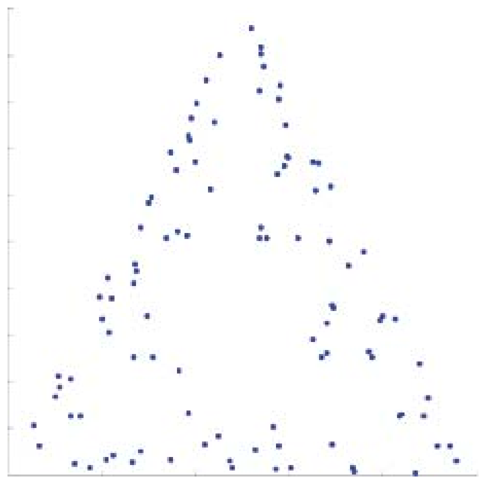

Fig. 2. The Sierpinski triangle resulted from the game of chaos based on Barnsley, STEPS 100

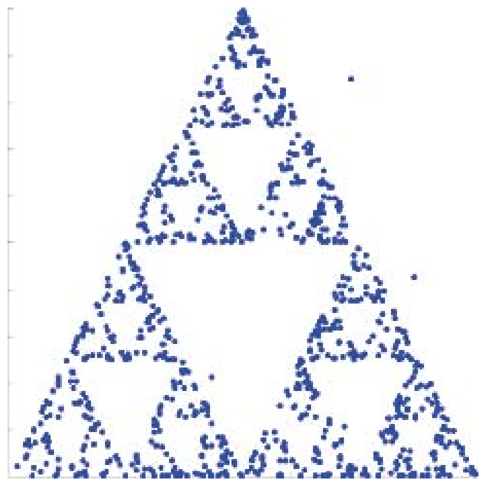

Fig. 3. The Sierpinski triangle resulted from the game of chaos based on Barnsley, STEPS 1000

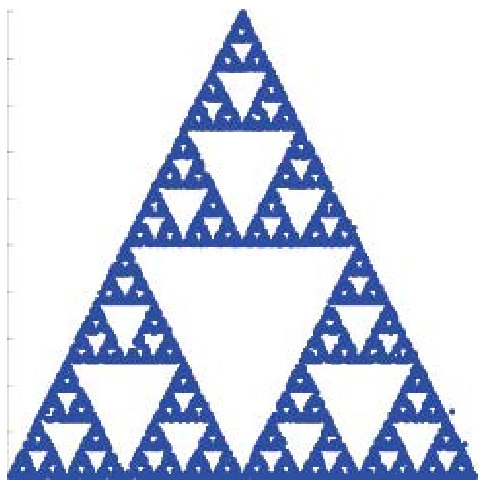

Fig. 4. The Sierpinski triangle resulted from the game of chaos based on Barnsley, STEPS 10,000

We built a simple interface as MATLAB Toolbox to construct different forms of pattern using different length and angle of branch, with the interface as shown Figure 5.

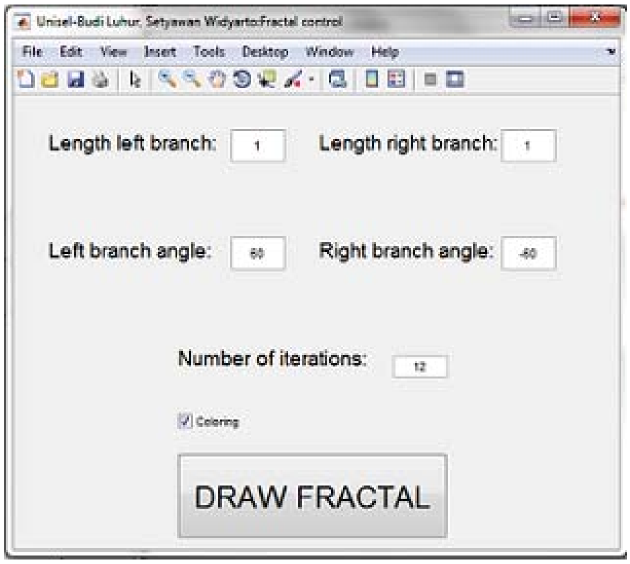

Fig. 5. Fractal toolbox

The pattern is a simple fractal with two branches generated left and right, but we use balancing branch neither left nor right as a seeder, a straight line or first iteration. It means, we cannot create something from nothing or zero, as human being never to be a creator.

This seeder must have physical dimension, Figure 6. The dimension is a certain length of line. However, we make the same values in every iteration in one execution of the simulation.

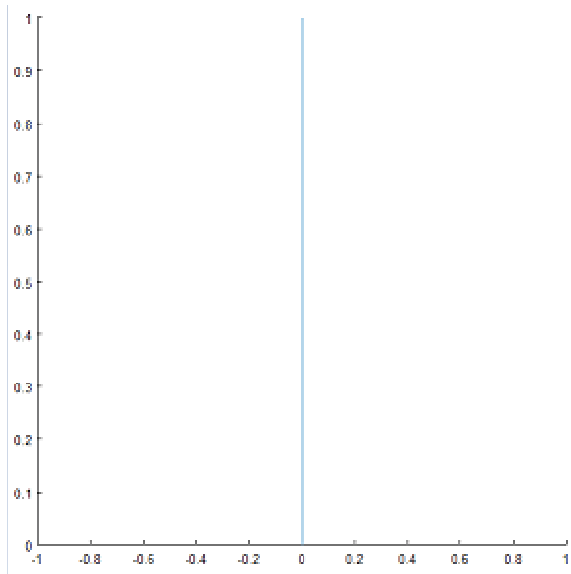

Fig. 6. Seeder of fractal

Then we make second iteration with a left and right branch. Both branches should have certain length and angle. Figure 7. Furthermore, with symmetrical length and angle 60 degreesproduce a bee-hive construction, Figure 8. Then we could create the variant of symmetrical and asymmetrical length and angle of branches (Figure 9).

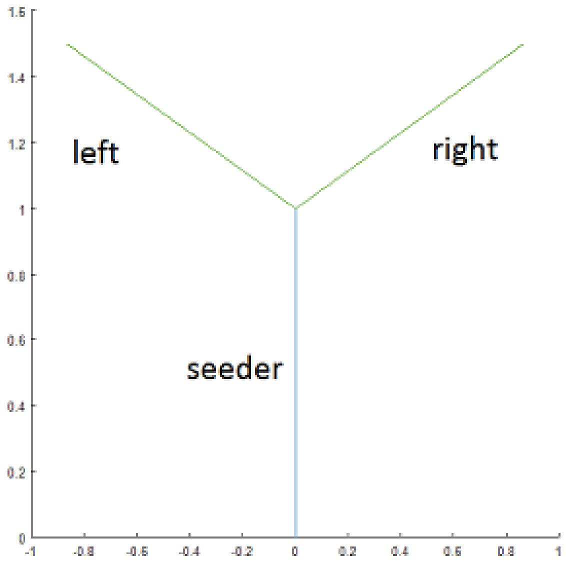

Fig. 7. Second iteration

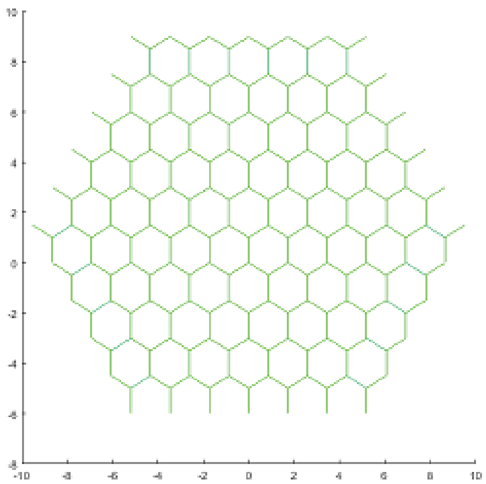

Fig. 8. Symmetrical

Ultimately, all coordinates resulted in the MATLAB Toolbox need to plot in 3D environment using Virtual Reality Modeling Language (VRML). Then, the simulation of fractal application is applied in shaping both in 3D using MATLAB and WRL software. An example of imaginary tree pattern can be produced using VRML in MATLAB. The valuable and remarkable shapes of any biological structures in 3D, Figure 10, produce an attractive shape of plantation and might be used to identify the real tree pattern.

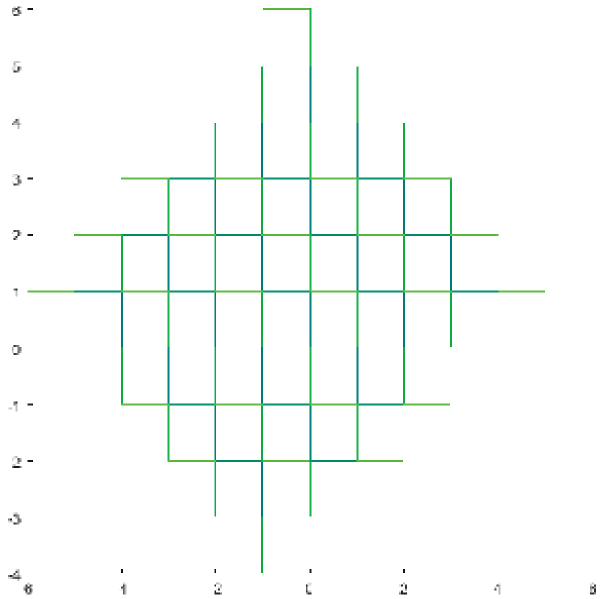

Fig. 9. Length not symmetrical

Fig. 10. 3D Fractal shaping

IV. Conclusions

A very significant pattern of fractal that can contribute toward a very complicated structure has been reviewed. Fractal study presented in this paper introduces a very significant result in producing simple to complicated structure based on pairing function. Ultimately, uncountable nature fractals may be produced as Al-Qur'an says. These phenomena mentioned in Al-Qur'an really open a lot of opportunity for scientists to get involve. To approach a complex of natural fractal and identify a pattern of the existing shape, a segmentation method is suggested. The purpose to inverse problem in fractal is how to identify a pattern of the existing shape and finally to determine a seeder of any fractals.

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