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Analysis of the Leaf Fractal Dimension

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Abstract :- The present study deals with the analysis of leaf shapes in terms of fractal geometry with medicinal plant like Hibiscus Leaf, by using the techniques of Image Processing. Fractal analysis has been applied to describe various aspects connected with the complexity of plant morphology. In this work we determined the fractal dimension of leaves for four methods like Prewitt , Sobel , Roberts , Canny . We summarize the different methods that have been developed for estimating the fractal dimension of medicinal leaves. The results are very informative.

Keywords: Image Processing, Peepal Leaf, Betel Leaf, Hibiscus Leaf medicinal.

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1.   INTRODUCTION

Nowadays, digital data is everywhere. Images obviously are one of the most important category among the available data. In this generation how the video, image and audio data is increasing and will continue increase in near future. Since it is difficult to deal with large amount of data, as the available data increases it becomes crucial to use the artificial tools for various purposes. Obviously, some part of this huge data volume comes from digitization of analog data and important portion of this digitized analog data is digitized historical data including images. Ancient images are quite important and valuable resources in the digital humanities. Because through this data, digital humanity scientists can get a rich playground for their research. So,digitisation and distribution of the documents in the form of digital image will have a great impact and will accelerate the ongoing research in digital humanities.

Considering the fact that images have not yet received as much attention as written sources, by using the image processing techniques, we can make the work much easier not only for now, but also for the future when there will be more data and more work to do on the images. Taking into account the sensitivity issues around the available original old documents, we can understand why digitization is important and the role that the image processing can play in digital humanities

Introduction to medicinal plants: Before there was modern-day medicine and its pharmacopeia of synthetic drugs, there were plants, and ancient civilizations knew how to use them strategically to treat common ailments and even life-threatening diseases. The ancient Egyptian Ebers Papyrus, a scroll from 1550 BC that's over 100 pages long, details 700 medicinal herbs and how to use them. The Greek Corpus Hippocraticum from the 16th century BC also details the use of herbal medicine.[1]

Later, during the 1800s and early 1900s, the knowledge of herbal medicine was passed down from one generation to the next. Typically, the woman of the house was well versed in the use of herbs for healing, and would act as the family's physician not only to treat illnesses but also to prepare various herbal wellness tonics and other remedies. Today, the World Health Organization (WHO) estimates that 80 percent of the world's population still uses traditional remedies, including plants, as their primary health care tools. Meanwhile, the majority of new drugs (70 percent) introduced in the US are derived from natural products, primarily plants. Unfortunately, the reverence for the use of medicinal plants in everyday life has largely been lost in the US. But if you are interested in using natural remedies to support your health, you should know that there are many right at your fingertips.

Medicinal plants have been identified and used throughout human history. Plants have the ability to synthesize a wide variety of chemical compounds that are used to perform important biological functions, and to defend against attack from predators such as insects, fungi and herbivorous mammals. At least 12,000 such compounds have been isolated so far; a number estimated to be less than 10% of the total. Chemical compounds in plants mediate their effects on the human body through processes identical to those already well understood for the chemical compounds in conventional drugs; thus herbal medicines do not differ greatly from conventional drugs in terms of how they work. This enables herbal medicines to be as effective as conventional medicines, but also gives them the same potential to cause harmful side effects.

Fractal

The term "fractal" was coined by Benoit Mandelbrot in 1975. It comes from the Latin fractus , meaning an irregular surface like that of a broken stone. Fractals are non-regular geometric shapes that have the same degree of non-regularity on all scales.

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Digital photography is a promised method for estimating the fractal characteristics of leaf veins. In this study, the effects of different threshold levels and image processing methods using Adobe Photoshop software on the fractal dimension values were examined from a digital photo of nectarine leaf. The results showed that the nectarine leaf vein has typical fractal characteristics and its fractal dimension increased linearly with the increasing levels of threshold. A larger value of fractal dimension was calculated from the image processed by dark strokes, and a smaller value by accented edges or desaturate. A positive relationship was found between the calculated values of fractal dimension and the black coverage in the image. Therefore, it should be cautious to choose threshold levels and image processing methods when processing a digital image for calculating the fractal characteristics of leaf veins.[1]

Veins of some leaves have typical fractal characteristics. Their box counting dimension calculated by some fractal software can be used for plant classification [2], [3]. But it took much time to prepare the leaf samples used for scanning photos of leaf veins, because of the difficulty of retaining only leaf veins and removing other leaf parts. With the development of digital camera and image processing, a clear digital photo of leaf can be non-destructively obtained by some image processing software such as Adobe Photoshop after capturing it in the filed. Then the processed photo can be directly used for fractal analysis of leaf veins. However, the information is meager for the effect of image processing method on the calculated result of fractal dimension of leaf vein.

2. RELATED WORK

The review article [4] emphasizes that the increasing number of applications of fractal theory in the environmental sciences reflects the recognized Importance of spatial and temporal scale to the study of ecological systems and processes. In this paper, we summarize the various algorithms that have been developed for estimating the fractal dimension of such natural phenomena as landscapes, soils, plant root systems, paths of foraging animals, and so forth. We also discuss the potential utility and limitations of a fractal approach, and outline how fractals have been used in ecology.

The review article [5] on Recognition of plant leaf images is an important and difficult task. Extracting the texture feature of leaf images becomes the key to solve this problem in recent years. Considering some wavelet methods only focus on low-frequency sub-bands of images and some fractal dimension methods using a single exponent also cannot identify the images well, a novel wavelet fractal feature based approach for plant
leaf images recognition is proposed. Firstly, the preprocessed leaf images are pyramid decomposed with 5/3 lifting wavelet transform and sub images are obtained. Then fractal dimensions of each sub images
are calculated to be the wavelet fractal feature of leaf images. Finally back propagation artificial neural network is used to classify plant leaf images. The experimental results show that the proposed method can improve the performance for plant image recognition compared with methods using only wavelet or fractal dimension.

In [6] a review article on Fractal dimensions of leaves from Cercis canadensis L., Robinia pseudoacacia L., Amelanchier arborea (F.Michx.) Fernald, Prunus persica (L.) Batsch, Quercus alba L., Carpinus caroliniana Walter, Ficus carica L., Morus rubra L., Platanus orientalis L., and Ulmus rubra Muhl. were calculated. The values were then confirmed and compared by those obtained from box-counting method and the exponent values of density correlation function (first time in the literature). It is now proposed for the first time that there is a relationship between a fractal dimension of the leaf and a surface density of the image and was concluded that together with other measures, the fractal dimensions with surface density function could be used as a new approach to taxonomical study of plants.

In [7] studies on A novel method for detecting rice leaf disease using image processing technique called fractal dimension and chaos theory is proposed in this paper. The analysis of a diseased leaf is carried out according to its image pattern and fractal dimension, and especially box-counting ratio calculation, and chaos, are applied to be able to identify the disease pattern's self-similarity and to recreate the fractal. The image's self-similarity is the disease infected one which is same as when it is fully infected. This method is proposed as preliminary information for the development of an early detection system or for developing knowledge based expert system or decision support system.

In [8] a study on Organisms supports continual exchange with the environment so that they maintain in a state far from their thermodynamic equilibrium. The plants maintain themselves under low entropy conditions, a necessary prerequisite to life. The concept of fractal dimension to describe structures, which look the same at all length scales, was first proposed by Mandelbrot Objects are usually referred to as self-similar to indicate their scale-invariant structure. The common characteristic of such fractal objects is that their length depends on the length scale used to measure it, and the fractal dimension tells us the precise nature of this dependence. Estimation of fractal dimension of leaf shape was recently performed form various authors. We estimated Fractal Dimension of different kinds of leaves looking at their inner structure until to the cellular nucleus. The results of the applied methodology resulted rather satisfactory so that in following papers we will apply it to investigation of plant structures under different experimental conditions as plant stress and per oxidation

In [9] a review article Fractal analysis has been to describe various Applied Aspects connected with the Morphology of plant complexity. Tomato leaves and we have multiple sinuses Suggested That this complexity is related to the necessity of light penetration through the plant. The eggplant leaves have Between fractal dimension of the medium pepper and tomatoes. This Means That this Needs assure eggplant structure of light and temperature. From this

it That Follows Higher complexity of tomatoes Need to Develop by comparison with the other studied species. Some of the other works include ([10] to [15]).

3. PROBLEM SPECIFICATION

The main objective of the present study is to make a detailed analysis of same Indian Medicinal leaves in particular Hibiscus Leaf by using the techniques of image processing methodologies. Different samples are taken and the experiments are conducted.

ROBERTS OPERATOR

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial frequency which often correspond to edges. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

PREWITT OPERATOR

Prewitt operator edge detection masks are one of the oldest and the best understood methods of detecting edges in images The Prewitt edge detector uses the following mask to approximate digitally the first derivatives Gx and Gy. The following is a Prewitt mask used to compute the gradient in the x (vertical) and y (horizontal) directions.

-1	-1	-1
0	0	0
1	1	1

Gx

-1	0	1
-1	0	1
-1	0	1

Gy

SOBEL OPERATOR

The Sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3X3 neighborhood. The Sobel operator is based on convoluting the image with a small, separable, and integer valued filter. A Sobel edge detection mask is given which is used to compute the gradient in the x (vertical) and y (horizontal) directions

-1	-2	-1
0	0	0
1	2	1

G_x

-1	0	1
-2	0	2
-1	0	1

G_y

CANNY METHOD

In 1986 Canny proposed a solution to edge detection that proves to be optimal for step edges corrupted by white noise θ The proposed model also defines a strategy to deal with multiscale edge detection ν Optimality relates to three criteria:

- Detection: important edges should not be missed
- Localization: distance between the actual and located position of the edge should be minimal
- One response: minimizes multiple responses to a single edge

After some complicated analysis Canny came up with a function that looked very similar to a first derivative of a Gaussian These are the main steps of the edge detection procedure he developed:

- Convolve an image with a symmetric 2D Gaussian
- At each point, evaluate magnitude and direction of the gradient (perpendicular to the edge direction) θ Find the maximum of gradient magnitude along this direction

4. METHODOLOGY

In order to make a detailed analysis of the leaves, the codes are written in Matlab 7.50 Version.

In order to determine the perimeter of a leaf, the outline of the leaf needed to be identified. After the image was converted into a binary image, an edge detector (using the Sobel approximation to the derivative, returning points where the gradient of the image is maximum) and boundary maker (tracing the exterior boundaries of objects) were used to create an image that is completely black with a pixel wide white outline of the leaf. This process did not ensure a continuous boundary thus a morphing application was used to "bridge" pixel gaps in the outline. With noted pixel locations outlining the leaf, "rulers" of standard measure were created by locating pixels "x" apart and the distance between these pixels was accumulated to determine the perimeter. The last distance that closed the outline was either calculated as stated or was determined by finding the distance between the last "x" away point and the first point used and added to the accumulation of distances to determine the perimeter. Vlcek and Cheung (1986) state that

848

"Mandelbrot defined the fractal dimension, D, to be an inverse of a least-squares estimate of the slope of a line given in the equation: $\log(N\lambda) = (1-D)\log\lambda + b$" where λ is the curve segment or ruler, and $(N\lambda)$ is the total length of the curve, and (1-D) is the slope of the line. Therefore the fractal dimension is found by subtracting the slope of the line from 1.

5. EXPERIMENT AND RESULTS

The main objective of the present study is the compare the results of the different methods and identify most optimal are the analysis.

The experiments to analyze the leaves of medicinal plants are conducted by using Matlab (Version 7.5). In Order to study the fractal dimension, number of pixels, Hibiscus leaves considered. The results are presented in Tables 1 to 4, and Graphs 1 to 4.

The color images, regardless of size, were converted to grayscale. With the use of several Matlab image processing functions, the outline of the leaf was obtained; white outline on black background. Another imaging procedure was used to obtain the pixels of the outline
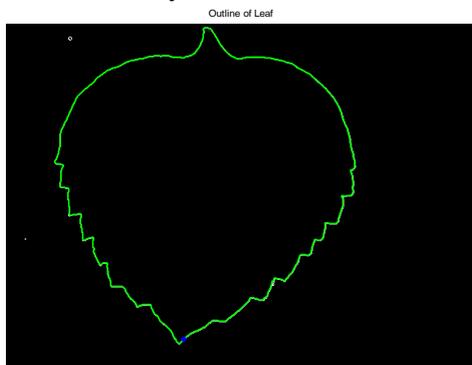

Figure 1 RGB & Gray Color Leaf

Figure 2. Boundary Detection Leaf

Perimeter method:

The perimeter method was used on leaves found on plants and trees. The color images, regardless of size, were converted to grayscale. With the use of several Matlab image processing functions, the outline of the leaf was obtained; white outline on black background. Another imaging procedure was used to obtain the pixels of the outline.

After plotting the outline of the leaf, the user is prompted to locate a pixel on the outline by using the outline figure and pixel information. For this particular example, the pixel (379, 186) was found to have a value of 1, "white" pixel, therefore on the outline. The point selected is noted in blue and the outline is "traced" in green westward from the initial point, indicating the continuous pixels identified as part of the outline.

Table 1: Prewitt Method

Sl. No	Prewitt Method			
	Data		Lambda	Distance
1	0.05	1.1388	3.912	7.0378
2	0.042	1.1742	3.7377	7.0682
3	0.033	1.2018	3.4965	7.0916
4	0.025	1.2233	3.2189	7.1093
5	0.016	1.2458	2.7726	7.1275
6	0.01	1.3007	2.3026	7.1706

Number of Pixels: 1242
Fractal dimension: 1.0747

Graph 1
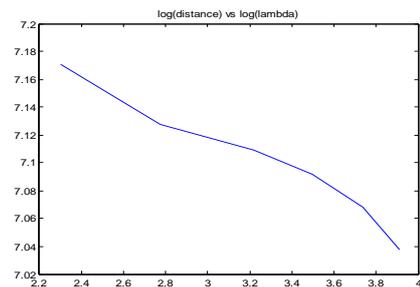
The outline pixels are in a p x 2 array, where p is the number of "points", pixels, used the make the outline of the leaf. The first and last "points" are the same, to enclose the leaf. The "ruler" is set to 50 pixels such that the distance from the first point (initial point) to the 51st point is calculated. The 51st point becomes the "initial" point and the distance from this initial point to the 51st point (the 101st point in the original list) is calculated, and so on. All these distances are accumulated. If the last initial point is not the last point on the list, the distance between the last initial point and the last point is found and added to the accumulated distances.

Column one of "data" contains the "ruler" sizes (50, 42, 33, 25, 16, 10 pixel count) while column two contains the perimeter the leaf using such rulers. The log of perimeter versus log of ruler size is plotted. The slope of the best fit line is subtracted from 1 to obtain the fractal dimension.

Same procedure is employed for the other method and results are presented in Tables 2 to 4 and Graphs 1 to 4 respectively.

Table 2: Sobel Method

Sl. No	Sobel Method			
	Data		Lambda	Distance
1	0.05	1.1511	3.912	7.0485
2	0.042	1.1723	3.7377	7.0667
3	0.033	1.2019	3.4965	7.0916
4	0.025	1.2189	3.2189	7.1057
5	0.016	1.2548	2.7726	7.1347
6	0.01	1.2923	2.3026	7.1642

Number of Pixels: 1235
Fractal dimension: 1.0697

Graph 2

log(distance) vs log(lambda)
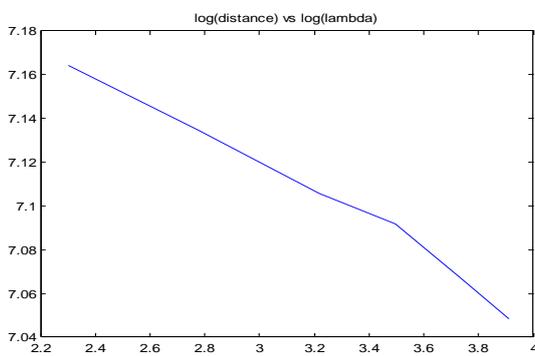
Table 3: Roberts Method

Sl. No	Roberts Method			
	Data		Lambda	Distance
1	0.05	1.1771	3.912	7.0708
2	0.042	1.1801	3.7377	7.0734
3	0.033	1.19	3.4965	7.0817
4	0.025	1.2298	3.2189	7.1146
5	0.016	1.2736	2.7726	7.1496
6	0.01	1.299	2.3026	7.1693

Number of Pixels: 1252
Fractal dimension: 1.0677

Graph 3

log(distance) vs log(lambda)
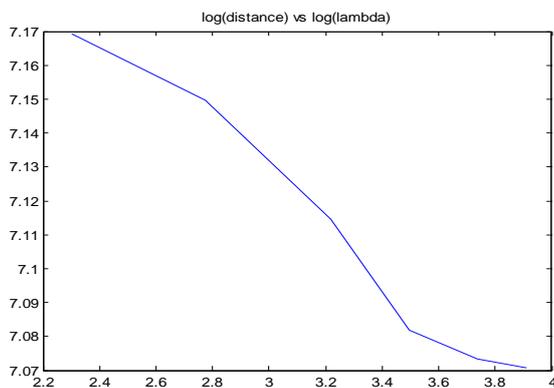
Table 4: Canny Method

Sl. No	Canny Method			
	Data		Lambda	Distance
1	0.05	1.199	3.912	7.0893
2	0.042	1.1514	3.7377	7.0487
3	0.033	1.1819	3.4965	7.0749
4	0.025	1.2131	3.2189	7.1009
5	0.016	1.2602	2.7726	7.139
6	0.01	1.2947	2.3026	7.1661

Number of Pixels: 1213
Fractal dimension: 1.0641

Graph 4

log(distance) vs log(lambda)
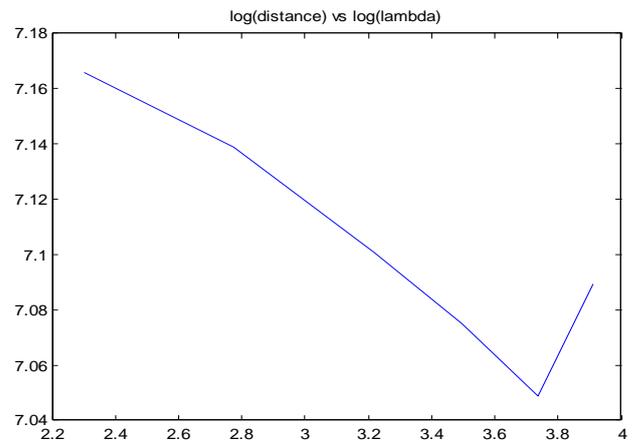
Table 5

Sl. No	Name of the Method	Number of Pixels	Fractal Value
1	Prewitt	1242	1.0747
2	Sobel	1235	1.0697
3	Roberts	1252	1.0677
4	Canny	1213	1.0641

Canny edge detection method is one of the most commonly used edge detection method. Sobel - method to detect edges in an image can be performed by locating pixel locations where the gradient is higher than its neighbors. Gaussian based methods - methods of edge detection using Gaussian.

1. One of the important predictions of the present study is that the value of fractal dimension is least in the case of canny edge detection method.
2. In the Table 5 provides the foundation for selecting an appropriate edge detection for the further edge detection. In fact one of the objectives is to predict an appropriate operator the capable of detecting boundaries based on intensity discontinuities.

Although the Sobel operator provides both differencing and smoothing, it detects part of the edges in the image. The

problem with the Roberts detector is that it relies on finding high spatial frequencies which fail to detect fine edges.

CONCLUSION

The fractal dimension can be used to quantify the shape of a natural curve , curves with similar degree of irregularity will tend to have the same fresh dimension.

The fractal dimension does vary among the different medicinal leaves because the edge is related to the complexity of this boundary and estimating the fractal characteristic of leaf veins. A larger value of fractal dimension was calculated from the image processed by dark strokes. And smaller values by accessed by edged or desaturate.

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