

UDC 681.03

FRACTAL DIMENSION CALCULATION METHODS AND THEIR USE IN THE TEXTILE INDUSTRY

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Abstract. *From the methods of calculating the fractal dimension, the prism method, the cube method, the method of counting cells, instructions on the methods of calculating the fractal dimension using set theory and the block diagrams of algorithms were developed. A software tool was created based on the Hausdorff method of calculating the fractal dimension. Fractal measurement determined by this software can be used in medicine for changes in the vascular system, in the accurate diagnosis of tumors in the brain, in the textile industry, in the textural analysis of the permeability and roughness of fabrics.*

Keywords: *Fractal, fractal dimension, determiner, affine, texturized, method Hausdorff.*

I. INTRODUCTION

In the world, the development and development of technologies for the use of fractal geometric shapes in the field of design of the textile industry remains one of the most important issues. Considering the creation of fractal images, the application of fractals in the field of textiles is divided into two parts. Firstly, fractal images are used in the design of textile patterns, and secondly, the properties of woven fabric such as permeability analysis, fabric defect detection, fabric surface texture analysis, etc. are analyzed based on the theory of fractals. The application of fractal images provides new creative ideas for designing textile patterns. Fractal theory is a powerful tool for solving complex problems in the textile industry.

Today, fractal geometry is a completely new direction of computer science and engineering research. Its possibilities are numerous and are demonstrated by fractal modeling of objects of complex geometry in nature [1,6]. This article introduces the fractal dimension related to fractals, the different methods of creating fractals, their properties and their applications. In this place, "Chasing time algorithm", "Random repetition algorithm", "Deterministic algorithm", "Affine substitutions", methods of calculating fractal dimension are analyzed. Fractals have properties such as self-similarity, fractional dimension, non-differentiability, infinite dominance, and occupying a limited area. If the parts of an object are similar to the whole object, it is called self-similarity. In Euclidean space, the dimension of a point is 0, the dimension of a line is 1, the dimension of a square is 2, and the dimension of a cube is 3. Such a measure is called a topological measure. But the fractal dimension is included in

the science as a Hausdorff dimension with a fractional value, which depends on the mass size of the images.

One definition of a fractal is that its dimension must be strictly less than its topological dimension [2,7,8]. The concept of topological measurement was introduced by Russian scientists P.S. Urison and P.S. Aleksandrovs identified. Based on the early concepts of classical geometry, plane shapes are two-dimensional, solids are three-dimensional, and are used only for gradation of geometric bodies. Because the topological dimension is an integer, and the dimension of the fractal is strictly less than it, then the dimension of the fractal is a quantity with a fractional value.

A fractal dimension is a numerical characteristic of a fractal. Y.G. In his works on fractal landscapes, Puzanchenko writes: "...fractal scale is an effective measure of complexity and provides information about the overall shape of the relief or the spatial structure of any component" [3].

II. FRACTAL DIMENSION CALCULATION METHODS

Different methods can be used to calculate the fractal dimension of each fractal shape. Fractal dimension can also be defined using set theory. To do this, one must first have a broader understanding of the Hausdorff dimension. The main feature of these dimensions is that it can be a fractional number rather than an exact whole number. Hausdorff scaling is more complicated than other types of fractal scaling, but it can be seen that the result is more accurate than other methods [4].

In practical problems that process images, in remote sensing systems, the fractal dimension is

often calculated by the cube method, coating method, based on local dispersion method, prism method and other methods. However, when processing the same image using different methods, the results are often different. In practice, when calculating the fractal dimension, it is necessary to choose an appropriate algorithm, taking into account the calculation accuracy, speed and system resources.

Fractal measure (Hausdorf - Bezikovich measure) describes how densely a figure fills the coordinate plane. For classical fractals, the fractal dimension is determined by overlaying an object, whose dimensions are estimated by predetermined geometric indicators. In principle, any geometric objects can be used as dimensions, but usually cubes for dimensional objects and squares for plane shapes are used as dimensions [5,9]:

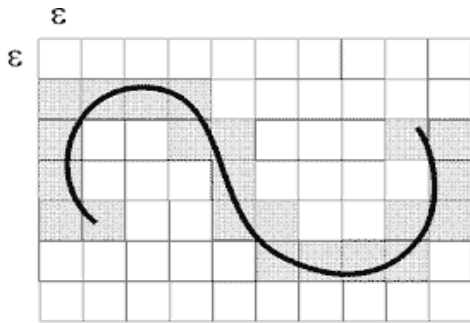


Fig 1. Fractal measurements determination

$N(\epsilon)$ - ϵ in size minimum number of squares let them be together analysis done fractal complete covers, then fractal measure as follows defined as:

$$D = \lim_{\epsilon \rightarrow 0} \left(\frac{\ln(N(\epsilon))}{\ln\left(\frac{1}{\epsilon}\right)} \right) \quad (1)$$

a real object fractal measurements fence coating using to determine one series methods there is Theirs between the most wide spread check box method . His algorithm as follows[10]:

1) Initially, in the plain fractal object next processing to give for comfortable to form transfer *need_Such* change for the most suitable procedure *is_raster* coordinates of the object fence with to cover through binary height to the map interpretation is to do:

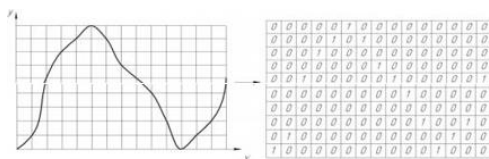


Fig 2. Fractal measurements determination

2) Next, check the box maximum size is determined $l = l_{max}$, it is a fractal measure determination need has been object *covers* Check the box maximum size determination for empirical relationships we install: $l_{max} = \frac{R}{10}$, here

$R = y_{max} - y_{min}$ - function values interval.

3) Har one in the cell units the number $N(l)$ is considered.

4) Check the box size shrinks: $l = l - 1$.

5) $l = 1$ if $N(l)$ and l values logarithmized, $\lg(N(l)) = f(\lg(l))$ function graph is made.

6) Function from the graph the smallest slope corner squares method through linear approach using is found. This of the corner tangent fractal is a measure.

According to the research results of domestic and foreign scientists, determining the fractal dimension by covering the object gives accurate results only for simple fractals, and this method of determining dimensions for random fractals is less effective.

In addition, the method of determining the fractal dimension by overlay has another important drawback - the result of calculations depends on the value of the initial cell dimension. For example, the fractal dimension was calculated using the software for different values of the largest cell dimension [11].

Also, deviation percentage is:

$$\Delta = \frac{1.854 - 1.22}{1.22} = 35\%$$

The calculation results are shown in Table 1:

Table 1. Fractal measure values

l_{max}	D
10	1.854
11	1.71
12	1.67
13	1.42
14	1.31
15	1.22

Also, with relatively small fluctuations of the fractal dimension values, significant deviations are observed.

Fractals random measurements determination for fractal measurements approximate evaluation methods work developed, their the main ones

power spectrum and Hearst indicator using measurements is to determine.

In the grid method of determining the fractal dimension, the fractal image is divided into squares of a certain size. At each iteration, the total

number of cells, the number of cells containing certain parts of the image, is counted. Based on these values, a linear equation is created and the coefficients are determined. The algorithm of this method is presented in Figure 3.

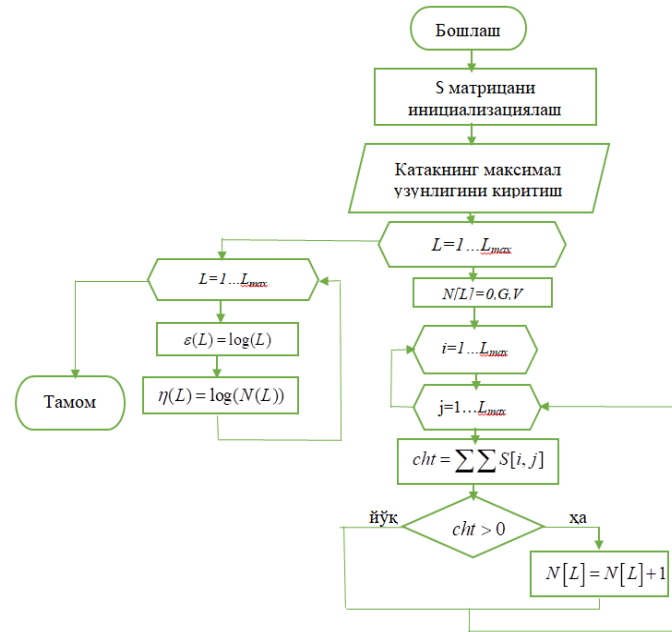


Fig 3. Block diagram of determining the fractal dimension by the grid method

A lot studies fractal of images power spectrum function to frequency reverse dependence showed:

$$S(\omega) = C_p \times \frac{1}{\omega^s} \quad (2)$$

If the values obtained in the formula (2) are logarithmized, then the frequency dependence of the power spectrum function is linear. The relationship between the fractal dimension and the slope of the power spectrum approximation

determined by the least-squares method is as follows:

$$D = \begin{cases} \frac{3+s}{2}, \text{ agar } s > 0 \\ \frac{5+s}{2}, \text{ agar } s < 0 \end{cases} \quad (3)$$

The block diagram for determining the fractal dimension for the power spectrum function is as follows (Figure 4) [5]:

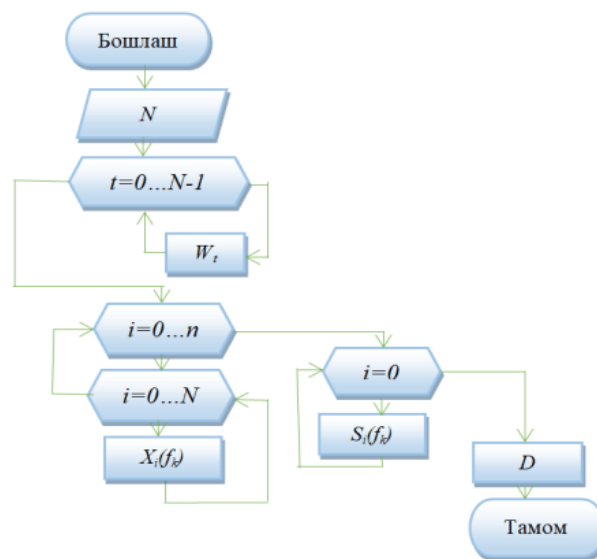


Fig 4. Block diagram of fractal dimension determination using power spectrum function

Fractal dimension:

$$D = \frac{5+s}{2} = \frac{5-1.33}{2} = 1.8.$$

A fabric woven from a thin thread that does not have an arbitrary surface is considered to have no volume. Therefore, its size is $D=2$. If we crumple it up and put it in a container and it completely fills the container, does this cloth now have surface area or volume? If it has volume, is the volume of the fabric equal to the volume of the container? Of

course, the size of the fabric is smaller than the size of the container. Because no matter how skillfully we place the fabric in the container, there will be empty spaces. So, the size of the fabric in the container is not $D=3$, i.e. $2 < D < 3$. Therefore, it can be concluded that along with whole sizes, there are objects of “fractional” size.

Based on algorithms (Figure 3, 4), a software package was developed for conducting computational experiments based on the Hausdorff method for calculating the fractal dimension (Figure 5).

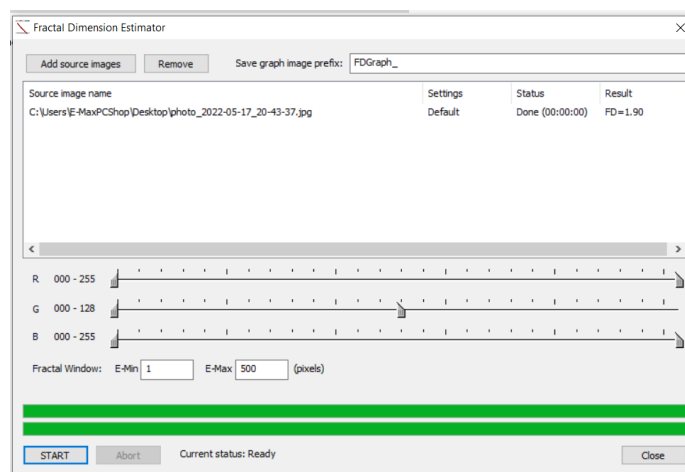


Fig 5. Fractal measure calculator program interface

V. CONCLUSION

In this paper, we focused on calculations of fractal dimension, prism method, cube method, cell counting method, and instructions were developed on methods for calculating fractal dimension using set theory and block diagrams of algorithms. A software tool was developed based on the Hausdorff method for calculating the fractal dimension; the results obtained can be used in medicine, agriculture, textile industry. In the textile industry, fractal measurement is used to determine the permeability of fabrics, and to analyze the texture of the surface of the fabric.

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Поступила в редакцию 3.10.2023

Citation: Ibrohimova Z.E., Asatov V.A. 2023. Fractal dimension calculation methods and their use in the textile industry. *International Journal of Theoretical and Applied Issues of Digital Technologies*. 4(6): 92-96.

МЕТОД РАСЧЕТА ФРАКТАЛЬНОЙ РАЗМЕРНОСТИ И ЕГО ИСПОЛЬЗОВАНИЕ В ТЕКСТИЛЬНОЙ ПРОМЫШЛЕННОСТИ

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Аннотация. Из методов расчета фрактальной размерности, метода призмы, метода куба, метода подсчета ячеек разработаны инструкции по методам расчета фрактальной размерности с использованием теории множеств и структурные схемы алгоритмов. Создан программный инструмент на основе метода Хаусдорфа расчета фрактальной размерности. Фрактальные измерения, определяемые этим программным обеспечением, могут быть использованы в медицине при изменениях сосудистой системы, при точной диагностике опухолей головного мозга, в текстильной промышленности, при текстурном анализе проницаемости и шероховатости тканей.

Ключевые слова: Фрактал, фрактальная размерность, детерминированный, аффинный, текстурированный, метод Хаусдорфа.

FRAKTAL O'LCHOVNI HISOBLASH USULLARI VA UN DAN TO'QIMACHILIK SANOATIDA FOYDALANISH

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Аннотация. Фрактал o'ichovni hisoblash usullaridan prizma usuli, kublar usuli, katakchalarni sanash usuli, to'plamlar nazariyasi yordamida fraktal o'ichovni hisoblash usullari bo'yicha ko'rsatmalar va algoritmlarning blok sxemalari ishlab chiqildi. Fraktal o'ichovni hisoblashning Hausdorf usuliga asoslanib dasturiy vosita yaratilgan. Ushbu dasturiy vosita yordamida aniqlanadigan fraktal o'ichovdan tibbiyotda qon tomir tizimidagi o'zgarishlar, bosh miyadagi o'simalarga aniq tashxis qo'yishda, to'qimachilik sanoatida matolarni o'tkazuvchanlik, dag'alligini teksturali tahlil qilishda foydalanish mumkin.

Калит so'zlar: Фрактал, фрактал o'ichov, deterministik, affin, teksturali, Hausdorf usuli.