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FRACTAL ANALYSIS OF NATURAL BOOK COVER SURFACES

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Abstract

Fractal geometry offers a new approach to describing the structure of different irregular objects, fractal design principles occurring in a very large number of phenomena from physics, chemistry, cosmology, biological structures, art. Fractal Analysis is a method used to study surface properties of biomaterials. It is suggested that the fractal dimension of a material is directly proportional to the amount of water, which it can retain, or that fractal dimension is proportional to porosity. In this paper the fractal analysis is used to determine how the environmental conditions influence the preservation of patrimony books.

Keywords: patrimony books, fractal dimension, HarFA soft, porosity

1. Introduction

Patrimony objects represent the material proves of evolution of the life's mode, intelligence and sensibility of humanity. Now more than in the past, the researchers use the advanced technologies in order to study and preserve the patrimony objects.

The investigation of the material's properties of the patrimony objects is necessary to understand both the reaction of the objects to the environment in order to create the optimal condition to preserve them and to act on the objects in order to decrease the degradation. The scientific research on some kind of materials (leather, paper, linen) is very important not only for preservation of the patrimony objects but, in addition, to obtain information about their age. For example, in the case of the textile objects, the characteristics of texture, the

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manufactory, colorants used and so on, can be good elements in order to stabilize the age, the provenience and, in addition, their authenticity.

Benoit Mandelbrot conceived fractals (from the Latin fractus = irregular) as a set of forms constructed by iteration, which are characterized by infinite detail, infinite length, no slope or derivative, fractional dimension and self-similarity [1]. The exponent of these properties is the fractal dimension and describes the self-similarity at different scales of processes and structures.

Fractal geometry offers a new approach to describing the structure of different irregular objects, fractal design principles occurring in a very large number of phenomena from physics, chemistry, cosmology, biological structures, and art. The fractals theory has been increasingly applied in the field of materials science and engineering. Models of fractal lines and surfaces have been generated to describe the microstructural features of materials. Special interest is placed upon a description of the fracture surface based on fractal geometry, in order to understand the crack path in materials. Several papers have demonstrated the relationship between the fractal dimension of a fracture surface and the values of roughness and fracture toughness.

2. Materials and methods

In this paper we tried to determine how the environmental conditions influence the preservation of patrimony books as 'Evhloghion' (Figure1).

The electron microscopy is a technique enabled to make studies on leather and textile morphology. Among all microscopic methods, the electron microscopy gives the best image resolution and the most accurate information on cristalinity, morphology of different structural types and surface structural topography [2].

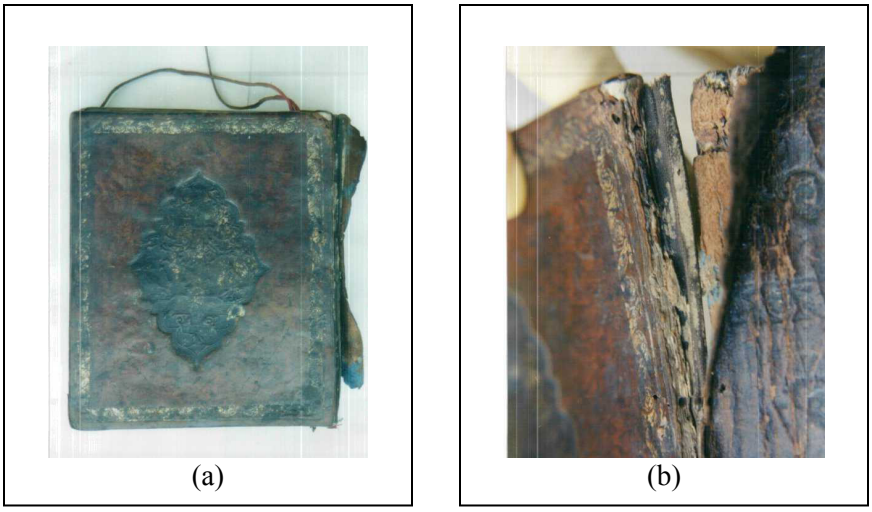

Figure 1. The old book Evhloghion 1854: (a) book cover; (b) back cover.

In this work we also used electron microscopy and fractal analysis to study the structure of old book covers surfaces. Samples from leather (Figure 2), paper (Figure 3) and other materials were preserved from old book covers. The samples were scanned with Scanning Electron Microscope Tesla BS-800 [2]. The same method we used for old paper

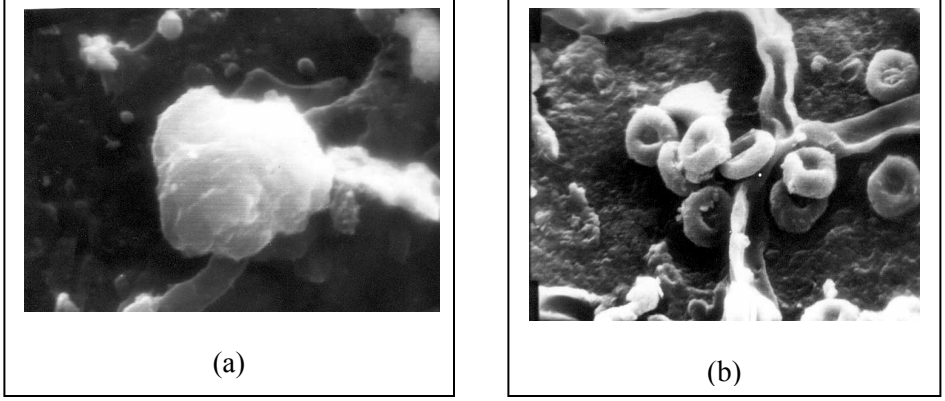

Figure 2. Sample from old leather book cover as seen by SEM: (a) magnification x1200; (b) magnification x12000.

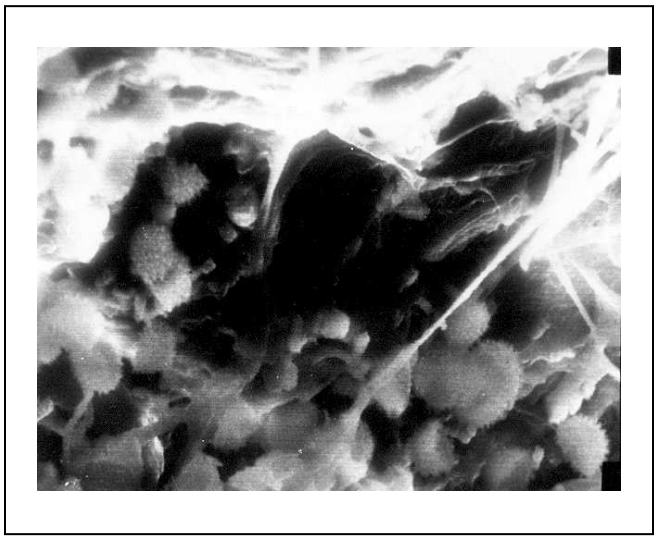

Figure 3. Sample from old paper book cover as observed by SEM (magnification x3500).

In order to identify the specific properties, which differentiate different samples, the fractal analysis based on Box Counting Method was used in this work. Box-Counting Method determines the fractal dimension of black & white digitised images of fractals. It works by covering fractal with boxes and then evaluating how many boxes are needed to cover fractal completely. Repeating this measurement with different sizes of boxes will result into logarithmical function of box size and number of boxes needed to cover fractal [3]. The slope of this function is referred as box dimension, which is taken as an appropriate approximation of fractal dimension. HarFA specialized soft was applied to obtain fractal dimension for every samples. In HarFA we use modification of traditional Box Counting. By this modification we obtain not one, but three fractal dimensions DB, DBW, DW, which characterize properties of black plane DB, black-white border of black object DBW and properties of white background DW. The most important fractal dimension is DBW dimension, which is the slope of the straight line Black & White [4, 5].

3. Results and discussion

Our measurements showed that the average fractal dimension DBW is 1,265 for old leather book cover biologically altered and 1.34 for old paper book cover; this means different values (Figures 4 and 5). The DB for leather and paper has closed values but DW for paper book cover is higher than skin book cover.

We also studied by comparison, the old and the actual book covers from the different materials and we found that the fractal dimension is higher for old material book cover than the actual material cover book. It varies moreover for linen book cover than for lather book cover. In time, the damage of leather is less then the linen; this means the leather book covers are better than the linen book covers.

To characterize the surfaces as fractals we used fractal dimension. There are many other methods to determine the fractal dimension (Yardstick method, Mass-Dimension Method, Perimeter–Area Method, Slit-Island Method, Asymptotic fractal formulas etc.). Many other methods are employed to study the properties of the different surfaces.

Te-Hua [6] used x-ray diffraction, scanning probe microscopy and fractal analysis to study characteristics of crystalline structure, roughness and nanotribology of ZnO thin films deposited under various power conditions.

Fractal Analysis is a method used to study surface properties of biomaterials [7]. Feder [8] suggested that the fractal dimension is proportional to porosity and that there is a direct relationship between the amounts of water withheld by a material and its fractal dimension. It is suggested that the fractal dimension of a material is directly proportional to the amount of water, which it can retain, or that fractal dimension is proportional to porosity.

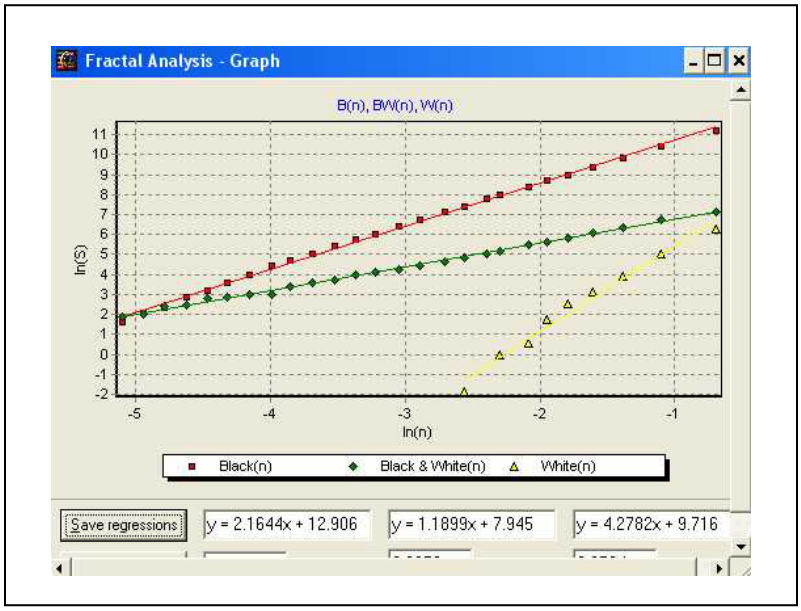

Figure 4. Fractal dimension for the sample from leather book cover.

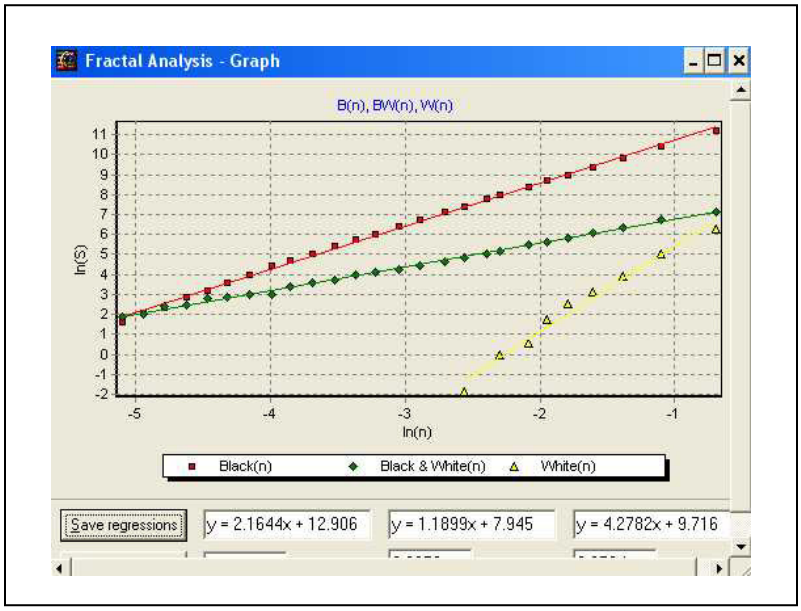

Figure 5. Fractal dimension for the sample from paper book cover.

Tang and Shiu [9] consider that the porosity of fractal aggregates can be calculated from the aggregate encased volume V_e and solid volume V as:

$$\varepsilon = 1 - \frac{V}{V_e} \tag{1}$$

A statistical and computational technique (DIG model) for analysing and extracting information from raster maps is presented in [10]. The spectral analysis is employed to study the machined surface profiles by Hasegawa and co-workers [11] and the same method was used to assess the effects of the stylus tip radius on measuring the surfaces profiles [12].

In this work we determined the planar fractal dimension (2D) with the aid of the above mentioned photos but for better results we will use the 3D fractal dimension in the future and we will connect it with the porosity.

4. Conclusions

In this work we pointed out the importance of concept of fractal structure in physical characterization of materials. The fractal dimension is higher for paper book cover than the leather cover book. Because DW for paper book cover is higher than skin book cover, this means that in old paper halls appear because of damage process. The suggested conclusion is that the leather book covers are better than the paper book covers.

The fractal analysis can contribute to a better understanding how the environmental conditions influence the preservation of patrimony books.

New methods of investigation and a new method to determine the fractal dimension for book covers are necessary in the future in order to understand how the porosity of these organic materials is connected to the fractal dimension.

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