

# **The Fractal Dimension as Alternative Theoretical Tool to Examine and Develop Urban Patterns**

## **Case Study – Korça, Albania**

**Denada Veizaj**

Polytechnic University of Tirana  
Tirane, Albania  
denada.veizaj@yahoo.com

**Gjergji Islami**

Polytechnic University of Tirana  
Tirane, Albania  
gjerislam@yahoo.com

### **ABSTRACT**

Contemporary theories on urbanism admit the complex nature of the urban fabric. This means that reading and understanding urban facts requires a much more complex theoretical model than the Euclidian Geometry can offer. As Nikos Salingaros admits, we need to rethink the discipline of urbanism by involving algorithms as advanced developing tools. Urban patterns are produced by complex algorithms which describe their morphology and not just their geometry in Vitruvian terms. Especially in vernacular (self-grown) patterns is noted the presence of fractal algorithms as urban fabric generators.

This research intends to identify and evaluate the fractal nature of Korça's vernacular pattern by using the fractal dimension as measurement tool. By observing Korça's pattern is easy to note the phenomena of the self-similarity and of a morphological hierarchy transmitted across the scales. Through a multi-scale analysis this research aims to verify the hypothesis of the fractal nature of this pattern. The self-affinity phenomena will be explored in the repetitive presence of specific planar motifs in different urban scales.

Theoretically, the fractal dimension controls the dispersion of mass over a structure and in this case it gives information about the fragmentation scale of the build environment. The measurement process is done by the use of the box-counting method and the Fractalyse software. On one hand the research identifies the fractal nature of a self-grown pattern; on the other one it raises an important question:

Can we list the fractal dimension as an additional parameter which gives more complete information about the urban morphologies?

**KEYWORDS:** fractal geometry, fractal dimension, urban pattern, box-counting method

## **1 INTRODUCTION**

Many studies and observations admit the specific and characteristic situation of urban structures and urban morphologies in Albanian cities. There is an intricacy, in terms of space identity, created by the co-existence of the Mediterranean ambiance and other historical influences, tracing in this way very specific urban patterns. Observing the urban fabric of Tirana it is easy to perceive the overlapping of chronologic urban layers. This fact produces the current space characteristics. The present urban tissue is

an amalgam of the local variant of Ottoman urban structure, the Italian traces of the 1920s, the rationalism period during the communism, and of the chaotic development after the '90s.

There are no rules in the co-existence between these different patterns. In specific cases, the mentioned situation creates tensions and controversies in terms of space identity and space qualities.

On the other hand the intense urban development of the last two decades is rapidly transforming the built form of Albanian cities, by threatening their physical identity.

## **2 THE MISSING SENSIBILITY VERSUS URBAN MORPHOLOGY ISSUES - THE INFLUENCE OF ADVANCED GEOMETRICAL SYSTEMS TO THE UNDERSTANDING OF URBAN FACTS**

The current urban space is the physical materialization of the failure of producing successful urban environment. The violent urban development is translated mostly in densification process especially in the internal areas of the cities. The densification process has produced overpopulated zones, problems with the infrastructure and degradation of the public space. As in existing urban areas, the same panorama appears also in the new zones developed during the last two decades. The problematic physical environment is also translated in other dimensions related to the urban space, as sustainability, identity, and the sense of belonging or the missing atmosphere of place (genius loci).

Referring to a descriptive analysis there are different factors of diverse natures causing this reality. It is possible to identify different groups of factors related to the governance issues, to the lack of development tools and the missing professional and research resources concerning urbanism.

In the first group the most fundamental factor remains the low efficiency of local governance and poor implementation of urban policies.

The other two groups of factors are both related. This research tries to introduce advanced theoretical tools in order to understand and evaluate the result (or manifestation) of distinct urban patterns in Albanian cities. The current lack of instruments and tools can be seen in two levels; theoretical tools to understand and analyse the urban context; development tools in practical level.

Referring to the last development plans, urban context analysis is done by using classic Euclidian models by avoiding the debate on urban morphologies.

At the same time development instruments, as regulatory plans, give only quantitative parameters of development, and nothing concerning the qualitative aspect of the built environment. The development of new zones of Tirana city is still done referring to the concepts of rational urbanism and socialism urbanism. Geometrically the current spatial development continues to refer to the crystalline model. (Alexander 1977) According to this model and to the urban environment that it produces, there are two main concerns to consider; is it possible to produce the macro-scale by multiplying the developed urban cells and how to respond to the missing atmosphere of place and identity?

Obviously new analytical and development tools are required; is it possible to search for answers using advanced geometrical systems as possible tool generators to better understand physical space? Is it possible to build an analytical tool for urban patterns based on these advanced geometrical systems?

The objective of this proposal is to introduce fractal geometry as an alternative theoretical tool to understand and develop urban patterns.

The main hypothesis remains that the fractal dimension value can offer an advanced tool to verify the presence of a fractal algorithm as generator of vernacular urban patterns in Korça city.

## **3 FRACTAL DENSITY VERSUS EUCLIDIAN DENSITY**

What is fractal geometry and what can it offer as opposed to Euclidian tools in terms of understanding and designing the urban space?

The main contributor of this theoretical model is B. Mandelbrot (1982). He says that the reference to fractal geometry helps to better describe the true nature of physical space. The Euclidian model of space based on x, y, z, axes is a simplified model. In fact the core concept of the fractal geometry remains the fact that there are no absolute 1, 2, or 3-dimensional objects; physical objects are better described by fractional numbers. So there is not an absolute straight line or an absolute planar surface.

Mathematically, the fractal dimension expresses this value, the fractional number describing the nature of the physical object. (Figure 1)

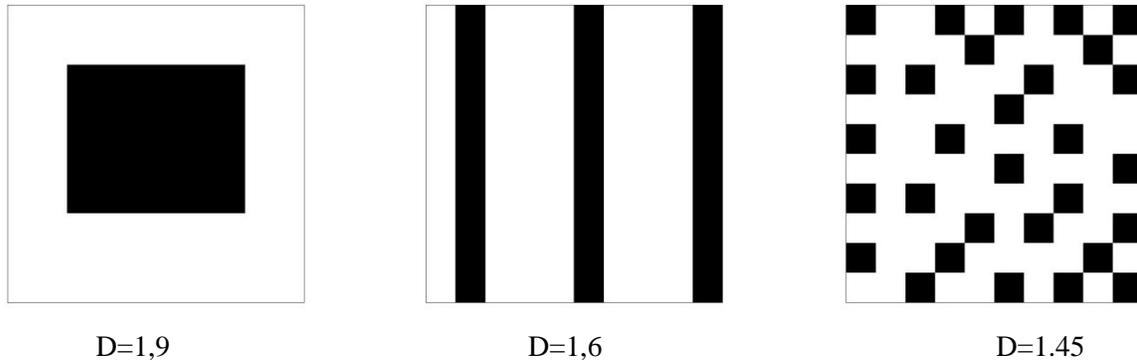


Figure 1: Comparison between fractal instruments and Euclidian instruments in terms of densities

By using the Euclidian density formula (ratio between the black and white surfaces) the value would be the same in the three cases, but in the Fractal density the value changes. Referring to this simplified example, we can achieve information not only about the geometry but also about the morphology of these patterns. This is a very important result; in this case the Euclidian density is the FAR (Floor area ratio); a general and widely used parameter to control the urban development in quantitative terms. On the other hand, the fractal dimension value controls the fragmentation scale of the build environment.

As we can see, measuring the fractal dimension of a specific urban pattern brings additional information concerning the urban morphology compared to the Euclidian methods.

As long as it controls the fragmentation scale, this parameter can be considered as an important element concerning the spatial identity of urban patterns.

The debate becomes more interesting if we use the fractal dimension also to measure the fractal nature of different kind of networks established on these urban patterns. There is a connection between the fractal values of the build environment and the fractal values of these networks?

In this research work, the fractal dimension is used to verify the presence of the fractal algorithm as space generator on vernacular urban patterns.

At the same time we observe that vernacular urban patterns appear to have specific intervals of fractal dimension values.

This research work relies on the previous work done by M.Batty (1996), P.Frankhauser (2009) and N.Salingaros (2006).

The key concept of their rhetoric remains the self-similarity and the self-affinity elements. In urbanism and in planning disciplines, the fractal geometry is used to describe the ability of structures to appear as non-scale organisms; by showing the same patterns despite the observation scale.

The main authors representing this topic are Michael Batty (1994) and Pierre Frankhauser (2009).

Michael Batty (1994) has done fundamental work on approaching fractals to city morphology. The concept of complexity in urban structure which is transmitted through different scales remains one of the

most interesting elements of his work and will be used as a key-concept during this research proposal. Pierre Frankhauser (2009) has done fundamental work on measuring the fractal dimension of different urban structures and has introduced two interesting concepts related to the mass dispersion over a structure; UI and FI (Uniformity index and relations between surface and perimeter). He also works on the hypothesis that there is a relation between the fractal dimension of the city Centre and the way that the marginal parts of the city evolve.

Nikos Salingaros (2006)'s work on "subconscious urbanism" explores the algorithm that people use while evolving urban space. He admits that the vernacular patterns are much more sustainable than the pre-planned urban forms. In fact he lists the fractal nature as an important characteristic of these patterns that contribute on their sustainability and identity.

Another important author feeding this research remains Serge Salat (2011). His work consists on examining historical patterns of different cities and comparing their fractal nature with that of the modern urbanism. His hypothesis is based on his conviction that modern urbanism caused a rupture to the cities multi scale nature.

Other interesting involvements of fractals in urban design see this geometrical system as an alternative method of producing spatial contexts. Designers use to refer to Euclidian systems or classic elements as point, line, and plane to produce space or form. The core concepts involving fractals in design process is based on seeing fractals as alternative generative tools which contribute on the expansion of the formal vocabulary of architects and designers.

#### **4 THE EXPERIMENT: MEASURING THE FRACTAL DIMENSION OF KORCA'S VERNACULAR URBAN PATTERN BY USING A MULTI-SCALE METHODOLOGY**

According to M. Batty (1994) and P. Frankhauser (2009), it is difficult to identify directly the presence of a fractal algorithm in an urban context, but most part of urban patterns are still evolved under the Sierpinsky carpet algorithm. To measure the fractal nature of an urban pattern the interpretation of the fractal dimension value and of the road pattern motif in different scales are required.

On the study case the measurement is done by the use of Fractalyse Software developed by Thema Group<sup>1</sup>.

By using the Box-counting Method it is shown how the fractal nature of a specific pattern can be measured. Also an analysis concerning the road pattern repetition over different scales is done to contribute the understanding of fractal algorithm.

By combining these analytical tools, data concerning the morphology and the fragmentation scale of a pattern are produced.

The procedure of evaluating the fractal nature of a specific pattern by using the box counting method

The calculation is done in different scales in zooming logic; according to the self-similarity concept the fractal dimension value measured in different scales should vary on similar values. This fact verifies the repetition of the urban fabric over scales, by consequence the fractal nature of the pattern.

The calculation is done referring to the box-counting method and by the use of Fractalyse software.

The main problem which also influences the experiment results is choosing the observation scale. In this case we have followed the patterns created by the roads network. The roads taxonomy defines also the urban clusters.

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<sup>1</sup> Thema (Theoriser and modeliser pour amanager) Research Laboratory – Universite de Bourgogne

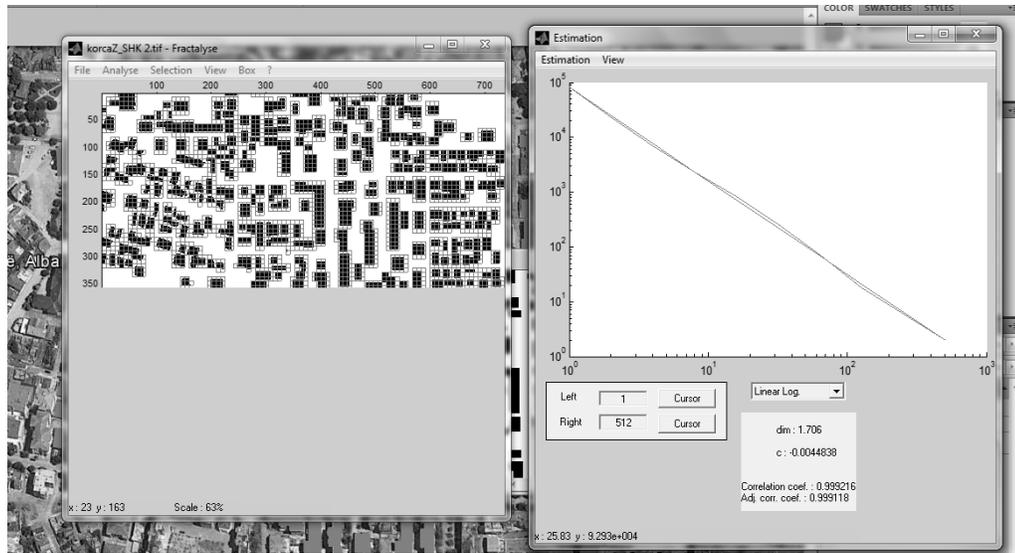


Figure 2: Measuring the fractal dimension of the Korca's vernacular pattern using Fractalyse as software. Fractal dimension value 1.706; Scale 1

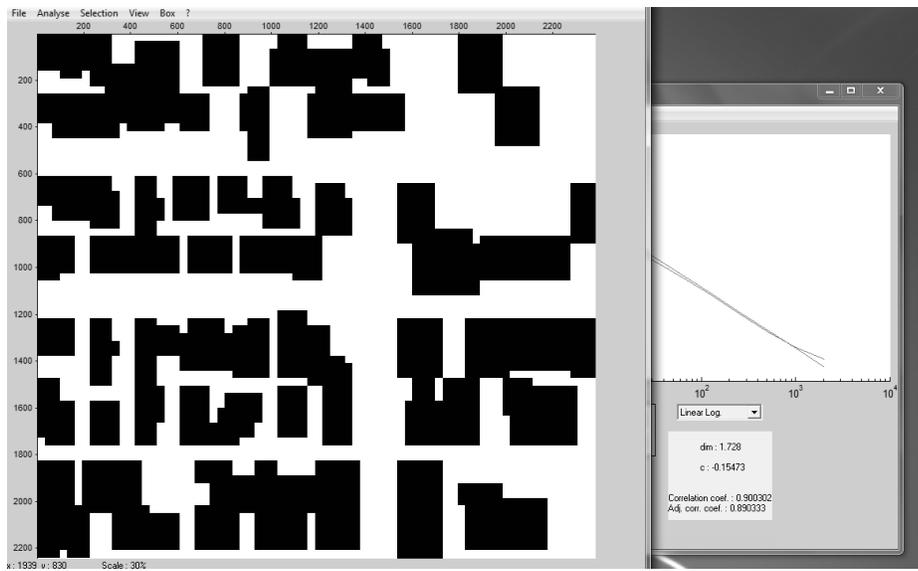


Figure 3: Measuring the fractal dimension of the Korca's vernacular pattern using Fractalyse as software. Fractal dimension value 1.728; Scale 2

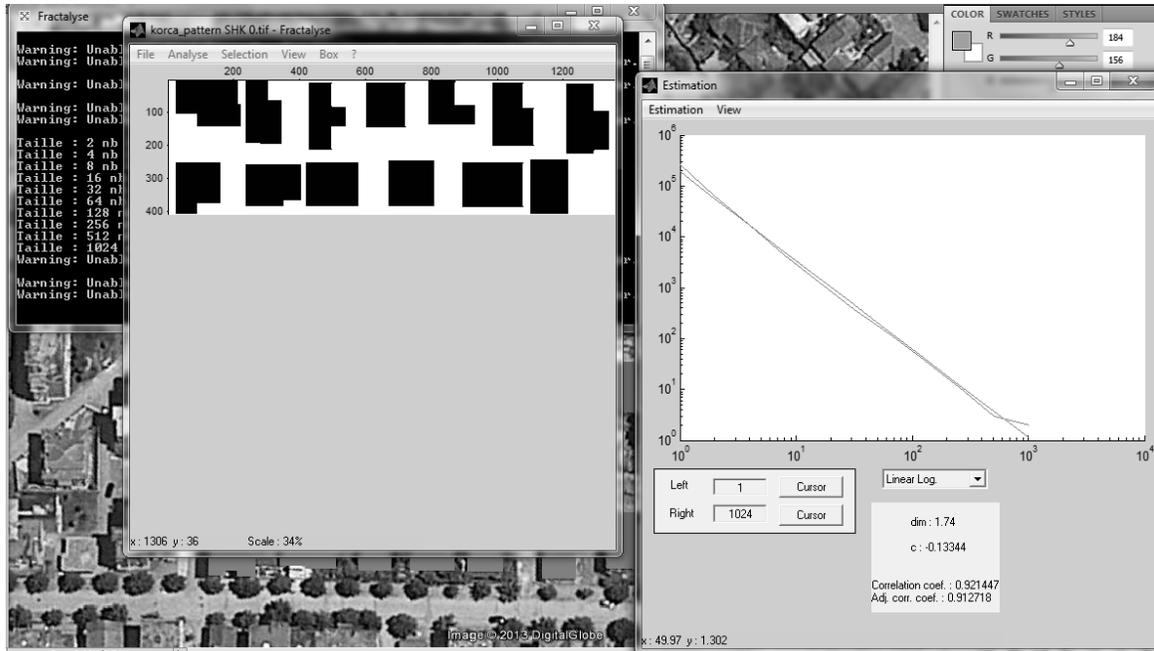


Figure 4: Measuring the fractal dimension of the Korca's vernacular pattern using Fractalyse as software. Fractal dimension value 1.74; Scale 3

By the metric analysis of the road network is shown how the road taxonomy defines the urban clusters by defining in this way the observation scale for measurement.

The fractal nature of the pattern is reflected also in the road network; by calculating and obtaining similar values of the network densities in different scale we observe the non-scale characteristic and the recursive repetition of motifs.

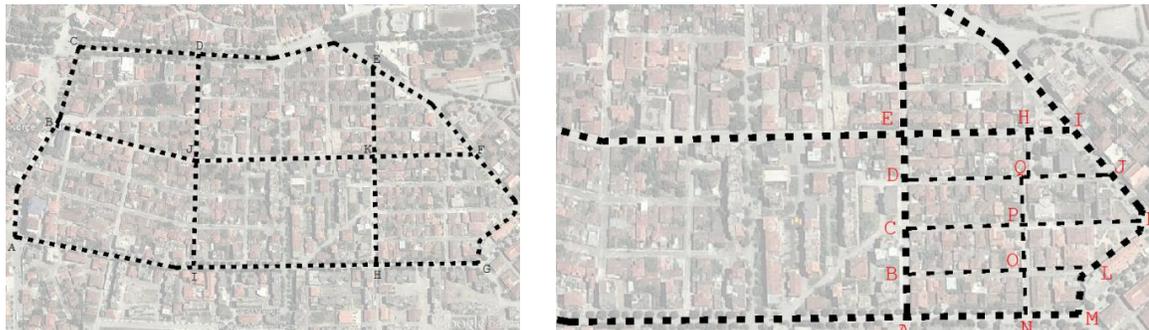


Figure 5: Calculating the road network densities in different scales. Obtaining similar values ( $D=0.56$ ) shows the same level of complexity transmitted through scales by verifying the fractal nature of the pattern.

## 5 CONCLUSION

The use of the analytical fractal model on a two dimensional (2-D) urban morphology map produces data that can be interpreted in different perspectives;

First, what is the meaning of a specific fractal dimension value in terms of spatial qualities and scale of fragmentation? As long as it controls the fragmentation scale it can be considered as an element

contributing to spatial qualities and space identity. Can it be used as a generative tool to the further densification of patterns by conserving space characteristics?

Second, there is a correlation between the fractal dimension scale and the road patterns or density in a specific urban tissue.

These two facts can generate further research questions such as;

- Can we build a generative urban tool based on the fractal dimension (densification of patterns) by transmitting the urban identity?
- Can we control the peri-urban development by analyzing the internal urban fabric of the city?
- Is there any connection between the fractal nature of urban patterns and their performance in economic terms?

## REFERENCES

AD-Architectural Design: Patterns of Architecture, Vol. 79, No.6, Issue 2, pp. 28-38.  
November/December 2009

Alexander, C. 1977., A pattern language. Towns, buildings, construction. Oxford University Press.  
California

Batty, M. Longley, P. 1994: Fractal Cities. Geometry of form and function. San Diego. Academic Press

Frankhauser, Pierre. 2009: Fractalite des structures urbaines, Antropos, Paris

Salat, S. 2011., Les villes et les formes: Sur l'urbanisme durable, Hermann, Paris

Salingaros, N. 2006. A theory of architecture. Solingen. Umbau&Verlag

Web-1. <http://urbanmorphologylab.com/team/serge-salat>

Web-2. <http://www.spatialcomplexity.info/archives/author/michael>

Web-3. [http://thema.univ-fcomte.fr/\\_Frankhauser-Pierre\\_](http://thema.univ-fcomte.fr/_Frankhauser-Pierre_)

Web-4: <http://zeta.math.utsa.edu>

