Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 216 (2016) 766 – 777

Procedia Social and Behavioral Sciences

Urban Planning and Architecture Design for Sustainable Development, UPADSD 14- 16 October 2015

# The Structural and Spatial Analysing of Fractal Geometry in Organizing of Iranian Traditional Architecture

Zohreh Kiani [a] , Peyman Amiriparyan [b,*]

[a,b] *Sama Technical and Vocational Training College, Islamic Azad University, Kermanshah Branch, Kermanshah, Iran*

**Abstract**

Geometry as one of the most influential elements has played effective roles in various structural, spatial and decorative (ornamental) systems in Iranian architecture. In this regard, three attributes of similarity, iteration and change in scale as the basic features of such geometry are clearly visible and assessable in the whole range of Iranian architecture. On the other hand, the mentioned three-fold features are the main characteristics of fractal geometry. Therefore, assuming the existence of fractal patterns in Iranian architecture is a probable and realizable issue and it deserves research and analysis. Therefore, the current article seeks to realize the premise of the existence of the fractal geometry in three scales of macro (city), medium (neighbourhood) and micro (building and motifs) in Iranian architecture specially, in cities of Isfahan and Yazd.


Peer-review under responsibility of IEREK, International experts for Research Enrichment and Knowledge Exchange

*Keywords:* Iranian Traditional Architecture_ Fractal Geometry_ Repetitive, Self-similar and change in scale Patterns_ Triple scales (Macro, medium and micro)

## 1. Introduction

Geometry as a mathematical concept has a fundamental role in Iranian traditional architecture. In a sense, Iranian architecture is inherently of a geometry-oriented nature (Falamaki, 2001). In Persian into Persian Dehkhoda Dictionary, geometry is referred to as a particular subfield of mathematics that studies and discusses space, shapes

* Corresponding author. Tel.: +989183583416
*E-mail address:* Peyman.amiriparyan@gmail.com.


Peer-review under responsibility of IEREK, International experts for Research Enrichment and Knowledge Exchange
doi:10.1016/j.sbspro.2015.12.074

and imaginable objects (Bemanian, Amirkhani, Lilian, 2010). Similarly, geometry and geometrical patterns in Iranian architecture is such a critical issue that, without paying attention to their structural role, the spatial-structural analysis of this type of architecture will be essentially descriptive. In addition, in case of the absence of geometrical structures at comprehensive system of traditional Iranian architecture, especially in Isfahan and Yazd, the nature of their spatial organization will undergo chaos and collapse. With a holistic view, it is possible to divide major geometrical factors in the formation of three systems including macro (city), middle (neighborhood) and micro (buildings) in the cities of Isfahan and Yazd under three broad features of similarity, iteration and change in scale. These features leads to to formation of diverse structural patterns with a similar origin in macro and medium scales, and different formal (ornamental) patterns in the micro system of buildings. Basically, triple features including similarity, replication and change in scale act as a generator and developer and are capable of embedding every geometrical cell in a systematic and complex mechanism as an inseparable part in a comprehensive structural, spatial and formal system. In this context, in case of the removal of the relevant cell, the whole subject is impaired.

Based on the scientific research carried on the function of geometry in Iranian Islamic architecture, and given that all three attributes including similarity, iteration and change in scale are the main factors of fractal geometry, it can be expressed that Iranian traditional architecture is essentially in a kind of conceptual-semantic connection with fractal geometry. Therefore, although the origin of such conceptual-semantic relationship cannot be Iranian architects' knowledge of the principle of fractal geometry in the past, it can be claimed that the patterns generated by them have common basic structures with geometric principles. Possibly, the process of Iranian architects' familiarity with this fractal pattern can be originated from natural sources (on the basis of fractal patterns found in nature) or geometrical sources with the presumption of the legitimization of geometric complexities to convert them into an architectural form. Assuming the presence of fractal geometric patterns in Iranian architecture, the current article shed light on the formation process of fractal geometrical patterns in the macro comprehensive system of urbanization, middle system of neighbourhood, and micro system of buildings and ornamentations (decorations). Furthermore, it is worth noting that, by using an interpretive approach, the article presents a spatial-structural analysis of the three-fold patterns mentioned above. Basically, interpretative approach, by a transition from description phase, generates an analytic perspective to explore the hidden layers of a particular issue. Therefore, to perform a case analysis of these geometric patterns with a monographic approach, some traditional patterns of Iranian architecture, ranging from micro to macro scales, are being analyzed. This analysis can be fallen into the category of monographic approaches. Notably, library and field studies are a positive step to collect information, which both methodologies are utilized in the present research.

### *1.1. History of fractal geometry*

Generally, after the advent of chaos and complexity theory in the mid-70s, fractal theory was emerged. Fractal is a new and non- Euclidean mathematical concept describing the complexities present in the nature in simple terms.

According to historians, the birth of fractals can be traced back to 1960s (Zarghami, Olfat, 2015). With the advent of the theory of fractals in mathematics, a new branch was founded under title of fractal geometry that can find some solutions to the complexities in nature in a principled way. In other words, it can be said that the basis of fractal geometry is built upon chaos theory. Basically, chaos theory is suggestive of order in disorder which its implicit order is much broader and complete than the Cartesian order (Gleick, 2005).

From a mathematical point of view, much effort has been made to establish the basic principles of fractal geometry, to the extent that fractal geometry was invented and introduced by Mandelbrout in 1975. Mandelbrot coined the term "Fractus" (i.e. irregularly crushed and broken stone) to introduce this geometry and it was named after the father of fractals (khakzand, Ahmadi, 2007). In fact, fractals categorize a wide range of issues that play historical roles in the development of pure mathematics under an overall title. The necessity of attention paid to this branch of mathematics is due to the fact that the geometry of the twentieth century has not the practical ability to interpret and describe various scientific concepts and hence, such branch of mathematics is able to describe and analyse the complexities in a practical fashion. The mathematical world of fractal incorporates richer possibilities that take steps beyond the structures seen in nature, so that the mathematics of the twentieth century has been able to have