CHAOS, DATABASES and FRACTAL DIMENSION of REGIONAL ARCHITECTURE

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The greatest defenders of new science state that the 20-th century will be called a century of relativity, quantum mechanics and ***chaos.*** *(Michael F. Schlesinger)*

Modern research on chaos started in the 60's from an incredible finding that simple mathematical equations can model systems as complicated as waterfalls. In the 70's some scientists in the USA and in Europe started to find their way through the chaos. They were dealing with different spheres of science: mathematics, physics, biology, chemistry, physiology, ecology, economy. In the next 10 years' time the term 'chaos' has become generally known in science. Scientists gather in research groups according to their interests as to chaos and secondly according to their scientific specialities. (Gleick 1996) Objects that described chaos were irregular in shape, ripped. In 1975 Benoit Mandelbrot called them fractals. Fractal dimension that described fractal objects was also his invention. Fractal dimension is a way to measure quality: the degree of harshness, uneveness, irregularity of a given object. Carl Bovill (1996) showed how one can use fractal geometry in architecture and designing. This very fact made me try to use fractal geometry to deal with regional architecture. What or who is the degree of regionality of a given object to be for? A specially qualified person is able to state it nearly automatically. However, regionality is in some sense an unmeasurable feature. While dealing with data basis or checking particular projects, creation of procedures of automatic acquiring information concerning regionality is becoming a necessity.

CHAOS

Even though it was already in the XIX century that Henri Poincaré noticed the outlines of chaos, the first confirmation of its existence was done by Edward Lorenz in 1963. Lorenz was carrying computer research on weather. He wanted to clarify why there were discrepancies between the weather forecasted and the real one. He made a mathematical model of atmosphere composed of 12 equations. The system of equations was beeing solved by computer. Accidentaly, to speed up the calculations, he introduced the intermediate values, which he got in a previous simulation. To make it easier, he rounded off the values from 6 to 3 places after decimal point (see Table 1). During the simulation of two months of weather this initially small difference of results became as big as the very signal from the beginning. In such a case if the real atmosphere behaves in the same way, it is impossible to forecast the weather months ahead. Even the most powerful computers won't be of help here; small mistakes would be growing to get big. The effect of sensitivity to the initial conditions was called 'the butterfly effect'. (It comes from Lorenz's publication 'Can the flap of a butterfly stir up a tornado in Texas?' In a TV interview Lorenz explains that the title concerning the sensitivity to the initial conditions was chosen by the publisher, and

personally to such a comparison he would have taken a seagull rather then a butterfly.) To simplify, it means that due to chaos, even the smallest events can have great consequences. (Figure1.)

It is difficult to deal with chaotic phenomena because in time of their exisence the areas of order mix with these of chaos. A new branch of mathematics – fractal geometry has been used to describe chaos. The word 'fractal' was thought up by Benoit Mandelbrot to describe, calculate and think about shapes that were irregular, broken, ripped. Winding coastline has not got length, it is unmeasurable. Even though, it has some characteristic degree of irregularity. The degree of irregularity for an object of nature is a constant number, independent of the scale, and is expressed by a fraction, hence the fractal dimension.

In the mid 80's fractal geometry has been used to examine polymers, problems of nuclear security. Fractal geometry gives a set of methods for physicists, chemists, seismologists, metallurgists, scientists dealing with theory of probability, and physiologists. In Hollywood computers and fractal geometry are used to create unusually realistic earthly and extraterrestial landscapes and film special effects. New Mandelbrot's geometry is becoming to be treated as geometry of nature. What's more, it gives mathematical and geometrical tool helping to describe and put forward hypotheses (Christopher Scholz).

DATABASES OF REGIONAL ARCHITECTURE

Computer data base concerning regional architecture uses data management system Microsoft Access. It is to help to preserve and continue the cultural landscape of Poland. On the area of Poland the state of preservation and resources of traditional forms are various. In order to be used, they must be examined, classified and then made available to the creators. (An example of existing information not being used is Polish Ethnographic Atlas, closely unknown to professional circles of architects.) A change of the architectural form of the house show Figure 2.

An attempt to create an example of a system to use relative databases in spatial and architectural designing includes direct and indirect applications. It is possible for different users to use the information from a base **directly** in various stated sequences. A problem arises when we want to use the data **indirectly** as modified elements of the base. For such a use of the base it is necessary to find the ways of „automatic" evaluation and modification of data base elements.

The need for architectural regional styles to exist has been widely and long discussed. Discussions become more intense when inspirations for new styles in architecture are looked for. The present intensification is connected with postmodernism ideas.

Together with the criticism of modernism, the search of inspiration in regional features of architecture has been started once again. The scientists have felt emotional relationship between the aesthetics of the new mathematics and the changes in arts in the second half of the XX-th century. For Mandelbrot modernism – economical, orderly, linear, geometrical – was the reflection of Euclidean geometry in architecture. About art which should give satisfaction Mandelbrot says that there is no scale in a sense that it contains important elements with all quantities. Regardless of the distance from which the observation is done, there are always details catching the eye. As we get closer, new elements appear in the field of view. Such is regional architecture – rich in details in every scale. 'The coast of England displayed a cascade from large bays down to small inlets. Traditional architecture also displays this cascade of large and small detail'. (Bovill 1996, p.45)

BOX-COUNTING DIMENSION OF THE REGIONAL ARCHITECTURE

In 1995 Ciesielski and Pogoda asked: 'Will it be possible to control chaos or to describe other phenomena seamingly distant from mathematics, for example the works of art ?' In 1996 Bovill publishes a book written for architects and designers, where this question is partly answered. The author shows the applications of fractal geometry, for example in architectural and design criticism to evaluate architectural objects. He uses examples of Wright's Organic Architecture and Le Corbusier's Purism in architecture and painting. The use of fractals on the stage of creation of architectural conception is shown on the example of deconstructive architecture.

Box-counting dimension is a special case of Mandelbrot's fractal dimension. It is most often used in different fields of knowledge. This results both from simplicity and possibility to automatize the calculations as well as from the fact that this dimension can be applied to shapes that are self-similar or not. I want to use box-counting dimension in 'mathematical' description of features of architecture regional values. In the present state of affairs it seems possible to express particular features of architecture through numbers. This applies both to single objects

and their sets. In such a case automatic checking if the existing objects possess accepted regional features becomes possible.

A computer programme was created to calculate automatically the box-counting dimension of scanned pictures of houses façades. It was assumed that houses can be the object of research concerning regional features by looking for their box-counting dimension. Traditional housing objects are the ones where regional features have been preserved up till now and are most visible. The result of such research would be the defining of box-counting dimension of architecture (both traditional and contemporary), which would have regional features. The procedure of calculation was described in (Zarnowiecka 1998b) - (see Figure 3).

Initial tests give no univocal answers. From the examples given by Carl Bovill we can deduce that for an object having in every scale details on a proper level, not only can one count its box-counting dimension, but also these dimensions will have similar values. The authors of the works quoted (Peitgen et al. 1996 vol.1, p.288) state that the box-counting dimension on a plane cannot be a value greater than 2. In the case of lack of ornamental detail the box-counting dimension will decrease rapidly in consecutive zooms. In the case of the calculation made for Le Corbusier's Villa Savoye it will come close to 1 (Bovill 1996 p.140).

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Table 1 Lorenz's experiment

repetitions	non stop	stop and make a new start
1	0,0397	0,0397
2	0,15407173	0,15407173
3	0,5450726260	0,5450726260
4	1,288978001	1,288978001
5	0,1715191421	0,1715191421
10	0,7229143012	0,7229143012
		to make a new start fror
10	0,7229143012	0,722
15	1,270261775	1,257214733
20	0,5965292447	1,309731023
25	1,315587846	1,089173907
30	0,3742092321	1,333105032
100	0,7355620299	1,327362739

(Peitgen et al.1996.p.82)

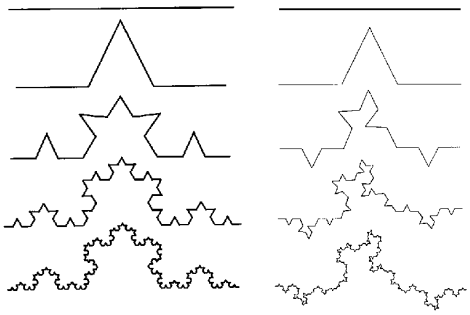


Figure 1. Part of the construction of a Koch Curve. A random Koch Curve (Bovill 1996)

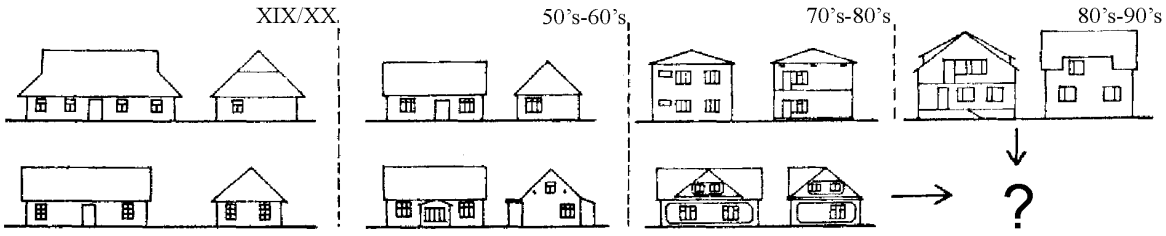
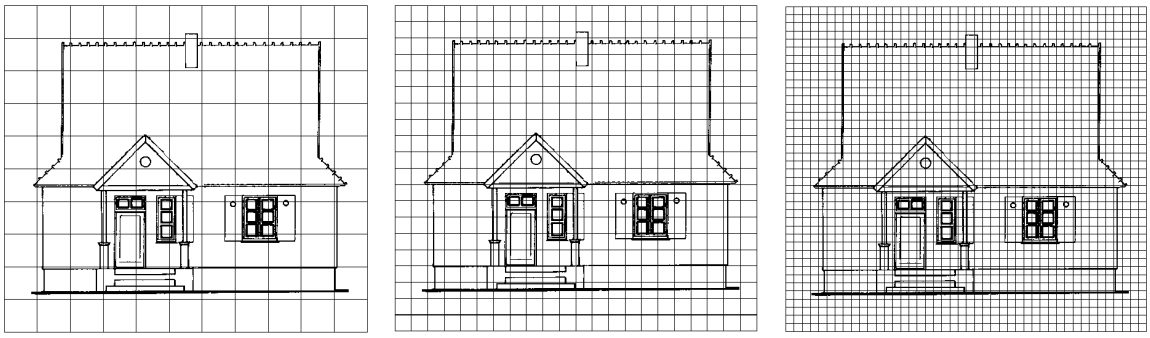


Figure 2. A change of the architectural form of the house (Zarnowiecka 1990)



Box Count for the Traditional House Elevation

box count	grid size	grid dimension	**Box-Counting Dimension**
49	11	160 cm	
129	22	80 cm	$D_{(box\ 160cm\text{-}80cm)} = \mathbf{1,497}$
334	44	40 cm	$D_{(box\ 80cm\text{-}40cm)} = \mathbf{1,569}$
930	88	20 cm	$D_{(box\ 40cm\text{-}20cm)} = \mathbf{1,477}$

Figure 3. Using the Box-Counting Dimension