



The New Role of Fractal Mathematics in Creating Human Friendly

Life-Extensions

“Friendship could only exist among good individuals”

Cicero, Roman historian, political writer, philosopher, 1st Century BCE

1. Introduction

The following caption, borrowed from the insightful observer, the late American-Canadian architectural critic and historian (1916-2006) Jane Jacobs, sums up the American, rather *North American* struggle to establish the right balance between the ever-growing despair of humanity at large and the possible rays of hope for possible improvements -- a process Jacobs describes as “unwinding vicious spirals” in order to heal the globe together with its dwellers.

“Cities happen to be problems in organized complexity, like the life sciences. They present situations in which half a dozen or several dozen quantities are all varying simultaneously and in subtly interconnected ways.... The variables are many but they are not helter shelter; they are ‘interrelated into an organic whole’.

Jane Jacobs, *The Death and Life of Great American Cities* (1961).

In her last book, 'Dark Age Ahead' (2006), Jacobs notes that we show signs of rushing headlong into a new Dark Age. Thus losing all we have achieved so far, particularly since cultures live through word of mouth and examples. Educators and mentors, whether they are parents, elders, or schoolmasters, use books and videos if they have them, but they also speak and also serve as examples themselves. Travel writers, novelists, visual artists, and photographers draw attention to subtle, everyday differences in conduct rooted in experience. A living culture is forever charging and changing, without losing itself as a framework and context of the charge. The reconstruction of a culture is not the same as its restoration. During a dark age, the mass amnesia of survivors becomes permanent and profound. The previous way of life slides into an abyss of forgetfulness, almost as decisively as if it had not existed. In such cases new ways are adopted without being examined and tested as all knowledge from the past is erased.

In the West, one of the first attempts of the application of fractal mathematics can be attributed to Italian scientist and mathematician Fibonacci who lived in the 13th century. The two examples of Fibonacci Numbers in spirals and flower petals are depicted below:

The florets in pineapples, sunflowers, daisies, and strawberries appear to form two systems of spirals, radiating from the center. Although they look like they are symmetrical, the numbers of clockwise and counterclockwise spirals are in fact not equal. When they are carefully counted they reveal a pattern of successive Fibonacci numbers.



In flowers the Fibonacci numbers are expressed in a very simple way. Flowers with one and two petals are relatively rare. Flowers with three petals are more common. There are many flowers with five petals and quite a few with eight. Daisies with 13, 21, 34, 55 or 89 petals are all quite common. While this is certainly not a fixed rule and any member in a species can vary from the pattern, what is quite remarkable is the regularity with which the pattern persists.

The work of mathematician George Cantor (1845-1918) produced the first fractals, which was the beginning of a new outlook on infinity-similarity-recursion technique. In the 1970s mathematician Benoit Mandelbrot has introduced Fractal Geometry of Nature to the West on a much greater scale. This new form of mathematics has entered in many areas of art and science with the aid of advanced computers, and has been able to describe the complex forms and patterns all around us like clouds, mountains, and flowers, and forests that the old Euclidean geometries could not explain. Mandelbrot's ideas and theories have revolutionized the way we see nature and all its complex diversity. They are now entering into architecture in a full-fledged way, and help dealing with all the complexities involved therein.

Much is to be learned from nature towards healing the wounds caused by up to now ill-behaving societies. Some useful lessons can be derived from the concepts and experiences of the artful patterns for living still in our memories and some still extant among indigenous and traditional communities, where there exists a natural propensity and invisible glue, which holds communities as a whole.

The above implies that such a development starts from the bottom initiated or launched by dwellers themselves and is the essential foundational step in creating conditions conducive to healthy and quality communications, which connect individuals and lead to the building of sustainable network communities living in harmony with nature. Such a picture must first come into focus in the minds of the people concerned. To trigger such images some help may work its way down from the top in the form of well-studied models representing variety of situations and sizes of communities. Fractals are very inspiring in this regard. Now with the help of super-computers micro-mesa/midi-macro model can be developed benefiting from fractal geometry and mathematics and stored as basic data.

Here we arrive at the place and the role of the systems approach and the interdisciplinary minds and versatile hands of architects and creators of communities, i.e., their inhabitants themselves. The latter -- by their natural propensity or education and experience as well as in depth observations -- must be and become integrated individuals by nature or by experience with a sense and good understanding of complex living systems.

“We somehow must overcome our ignorance, and learn to understand the city as a product of a huge network of processes, and learn just what features might make the cooperation of these processes produce a whole. We must therefore learn to understand the laws which produce wholeness in the city.” Christopher Alexander, Hajo Neis, Artemis Anninous, and Ingrid King: *A New Theory of Urban Design* (1987)

Some highlights of the ideas, theories and practical approaches on the recent research done by scientists and practitioners concerned with the creation of human-and environment-friendly settlement schemes, as presented by Michael Batty’ in his recent book (2007) on “*Cities and Complexity: Understanding cities with Cellular Automata. Agent-based Models. And Fractals*” are presented below in an improvised manner in support of the purpose of the paper.

Cities should be treated as emergent structures born from bottom up processes. Attempts to develop a theory for such a growth under experimental conditions are difficult owing both to ethical considerations as well as the much higher degree of openness and connectedness that social systems manifest. That is why cities, by and large do not develop in strict accordance with any grand plan. They are too complex and diverse to be controlled, too heterogeneous and responsive to their wider environments to be managed in their totality. In this sense, they are no different from any living system whose code of development and growth resides in its most local parts. Science is

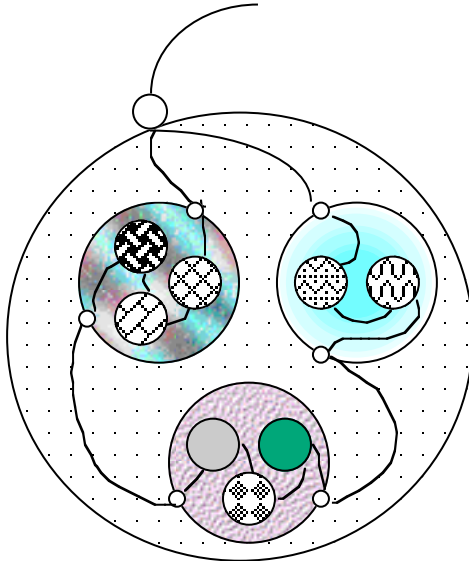
gradually getting used to the fact that complex systems are built from the ground up, and that the most efficient --- in fact the only possible --- strategy for the development of complexity is coordination of the parts at the most local level. The architecture of complexity is built from local actions that are coordinated in such a way as to produce well-integrated and workable systems differentiated hierarchically that at first sight might suggest the outcome of some central planning, but it is not. There are only the actions of individual elements whose coordination results from the unceasing and inevitable processes of competition and adaptation.

A fractal is an object - or a system of objects – that scale with respect to its various attributes, mainly its size. Fractals can scale along different dimensions, specifically the spatial or geometric but also through time, and across other classifications that order the objects with respect to one another. If an object scales, it appears the same or at least ‘similar’ at different levels or resolution or abstraction, hence the origin of the self-similar, which is often taken as the hallmark of a fractal. Like TREE, the object is fractal if the scaled branch has the same morphology as the entire tree.

The key to forming such fractals is the notion that a single process operates at different scale giving rise to this self-similarity. As in a cellular automata model, referred to in the Michael Batti’s above cited book, the neighborhood is the smallest cell of a settlement scheme to gradually grow into ever-growing structures by building connections in the process like a web. Spatial structure is thus our starting point, but fractal geometries reveal them as much in time, as space. Cities preserve themselves at their critical state,

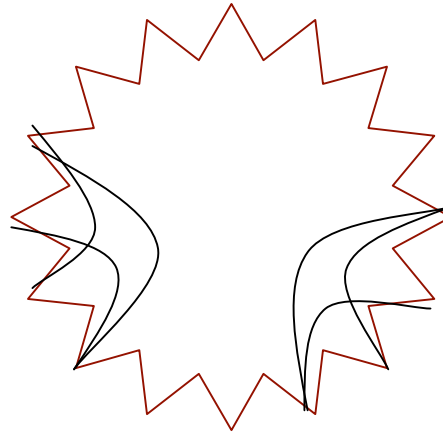
and it is only at this state that they are fractals, or so the argument goes.

Fractals for Systemic Integration



○ connecting points for auto - catalytic functioning

Process of a local cluster networking



Most, if not all complex systems are fractals, displaying organization or order on all scales. Cities, thus, life-itself, are intrinsically ordered and cannot exist in any other state. The contemporary city, which is clearly complex and highly ordered, is, hence, fractal. The resilience of complex systems, in practical terms a neighborhood-network, at their critical point is deeply dependent on their fractal structure.

The book “*Complex Spatial Systems*’ by Alan G. Wilson (2000) is one good source to probe into on the basic ‘*modeling foundations*’ for urban and regional settlement schemes based on the concept of fractals and their web-like growth patterns. They follow the ideas of complexity theory. They may play a major role in extending traditional, classical theories of cities and regions. At the root, their concepts that transcend disciplines, when clearly understood, extend and enhance the analytical capability in significant ways

integrating analogical thinking amplified with metaphors into practical insights or concepts in the fields of humanistic, social, economic and ecological systems.

Powerful computers now allow us to get closer to real answers to many queries within the infinite sphere of complex systems, including the prime components, such as people, organizations and infrastructure. They can be assembled in a very large number of different ways, at different levels, into the systems concerned, into which insights from all different perspectives can/must be combined in an effective way. This way the analysis can connect to a wide range of issues pertaining to inner city decay, urban-suburban transport, employment, and rural poverty, regional and national underdevelopment, environmental degradation and so on. This can provide insights to many students and practitioners with interdisciplinary propensities in the field of new human settlements and of reanimation of existing relatively declining communities, in other words, ‘architecturing of lively communities’.

2. Triggering further reflections in this field

Some hints are given below on the application of the concept of fractals to animated settlement schemes keeping the spirit of the past and longings for its life-giving aspects. Here fits in well the lament of the contemporary Kenyan Poet, most likely shared by many in his country and elsewhere, as it describes the passing of the old forms, the traditional way of life with the following lines, borrowed from Claudia Zaslavsky’s book “Africa Counts: Number and Pattern in African Cultures” 1973-1999:

“ The Round House”,

*“The round warm hut
Proud to the last
Of her noble sons
And daughters
Stands besieged*

*All this and much more,
Slowly and slowly disappears:
Slowly and slowly iron appears,
Lays a siege on the roof
And takes prisoner the pot and the gourd,
The plate, the cup, the lamp,
What’s this but a change
To the new oblong house?
The round mud hut is no more.”*



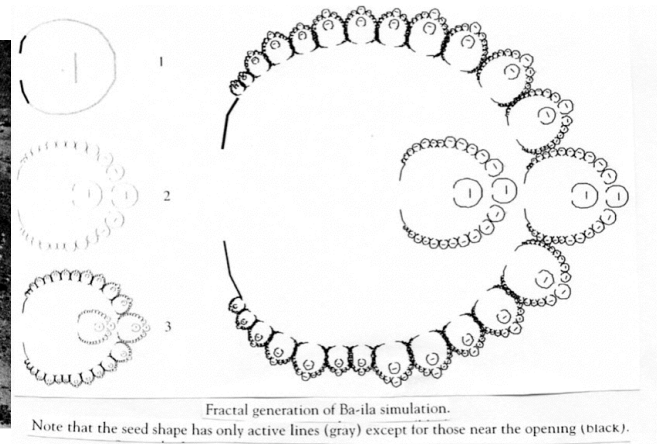
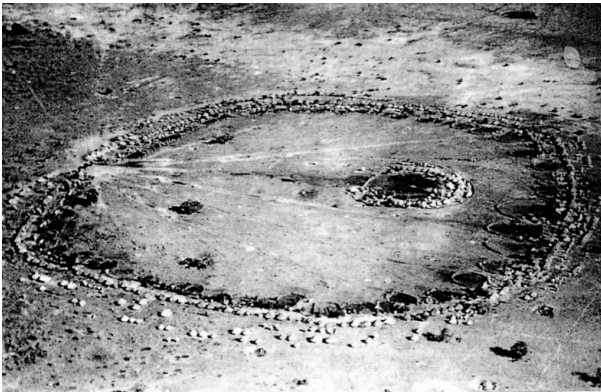
A beehive-shaped Chagga house (Mt. Kilimanjaro),
Village Museum, Dar es Salaam

The African used to adapt his/her home admirably to his/her means of subsistence. Much of southern Africa is made up of arid plains where herds of cattle and their available sustenance materials adapt to requirements of the climate.

3. Circular fractals in settlement architecture

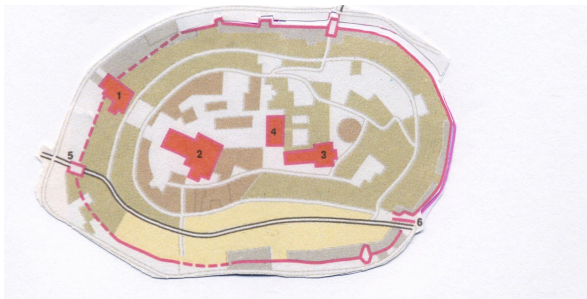
Ring-shaped livestock pens, one for each extended family, as shown in picture 1 & 2 below. Towards the back of each pen we find the family living quarters, and towards the front is the gated entrance for letting livestock in and out. For this reason the front entrance is associated with low status (unclean, animals) and the back end with high status (clean people). The geometric elements of this structure -

- a ring shape overall, and a status gradient increasing with size from front to back -
- echoes throughout every scale of the Baila settlement. The settlement as a whole has the same shape: it is a ring of rings. (From Ron Eglash, *African Fractals: Modern Computing and Indigenous Design – livestock are raised* (1999-2005).



A Ba-ila settlement before 1944, in southern Zambia.

The town has a very ancient origin. It has an elliptic form. It took its actual form during the 16th century. This new form and its central square with its elliptic theatre-cum-



A medieval jewel town: Lucignano-Arezzo, Italy

meeting place indicate the new ideas on the urban developments, which bring back the arena idea and its function in the social and every day life.

4. Arcology concept and its realization

Arcology is Italo-American architect Paolo Soleri's concept of cities, which embodies the fusion of architecture with ecology. The arcology concept proposes a highly integrated and compact three-dimensional urban form that is the opposite of urban sprawl with its inherently wasteful consumption of land, energy and time, tending to isolate people from each other and the community. The complexification and miniaturization of the city enables radical conservation of land, energy and resources. Arcology eliminates the automobile from within the city. The multi-use nature of arcology design would put living, working and public spaces within easy reach of each other and walking would be the main form of transportation within the city. An arcology's direct proximity to uninhabited wilderness would provide the city dweller with constant immediate and low-impact access to rural space as well as allowing agriculture to be situated near the city, maximizing the logistical efficiency of food distribution systems. Arcology would use passive solar architectural techniques such as the apse effect, greenhouse architecture and garment architecture to reduce the energy usage of the city, especially in terms of heating, lighting and cooling. Overall, arcology seeks to embody a "Lean Alternative" to hyper consumption and wastefulness through more frugal, efficient and intelligent city design.

Arcology theory holds that this leanness is obtainable only via the miniaturization intrinsic to the Urban Effect, the complex interaction between diverse entities and organisms which mark healthy systems both in the natural world and in every successful and culturally significant city in history.



Arcosanti (Arizona, USA):

A Settlement Scheme in process:

presently a unique near-
utopian settlement.

It is a kind of laboratory- cum – pilot scheme being created in Arizona, USA, which has already its citizens of 5000 voluntaries are working on its realization. With the words of the Construction Manager, an Italian Engineer/Architect Marco Felici: “ Participating to daily activities of Arcosanti Complex makes people aware that its urban effect is generated by people themselves, the architect being only one of the instruments in its creation. But the music is freely interpretable. The adventure continues the site being a continuing workshop, where now the work is accelerated towards proving the theory of Arcologia, involves a vertically growing city fermenting itself by air.

5. Kartal - Pendik seafront urban transformation project, Anatolian side of Istanbul

The redesign of this area is developed around a soft, flexible grid-work laid over and adapted to the urban fabric and the existing infrastructure system that forms the basis for different types building the program demands while retaining it clear and consistent image, thereby creating a soft, gradual transition between the denser and the more sparse built-up areas.

The new design creates a green area in the central core



of a former stone quarry with taller office buildings arrange around it. Down by the water, there will be a marina and an area providing cultural and recreational facilities, with congress centers and museums. A line of housing will be created between the two.

6. Conclusion

Concept and practice of fractals can advance a paradigm shift for the 21st century and beyond and are capable of enabling the creation of human and environment-Nature friendly dwellings. The principle approach could be ‘model building’ for diverse ecological and social conditions and the potential to nurture growth with limitations. In the generation of suitable models continuing experimentation, exploration of various solutions and their testing in the form of pilot schemes could be the dynamic way of producing alternatives to chose from. This may be the pattern of a dynamic paradigm, or rather process, respecting the principles of the broadened science of complex systems for the 21st century and beyond.

A broad-minded scientist and architect Von Neumann said already in 1966, “The sciences do not try to explain. They hardly even try to interpret. They mainly make models, a mathematical construct with some verbal explanation that describes observed phenomena. Then, it is expected that it works.”

Yes, such models fulfill a purpose. In reality it is only a fiction, but it still informs and triggers a further elaboration at each stage and so goes on. One starts the next movement

in an informed and enlightened ground. It sets the process of the initial plan of action, acting on it and monitoring the progress, which follows a circulatory dynamics with improvement in every step moving gradually towards infinity. In this process no entry functions alone, as in a relational structure any one entity continuously relates to and connects with many others.

The fractal is the nature of living systems as well as their symbol: fractals representing ubiquitous phenomena that emerge everywhere as a result of geometric-space constraints. All these arguments prepare the ground for the amplified and broader science of complex systems responding to the needs of living systems, such as organisms and human-social organizations, naturally growing in a bottom-up manner with unpredictable conundrums occurring at every side and level. Such an understanding and comprehension could only meaningfully exist at the people and community levels. In the end real development will be expected to occur through processes initiated and furthered by the people concerned. Ideas and formulated solutions may come from the (Teilhard de Chardin) notion of *the non-sphere* --- as inspirations, from documents or stories passed on from generation to generation in written form or through word of mouth or told by elders, through art exhibitions, archeological sites, museums as the custodian of all, as well as tutors and scholars and last but not least personal experiences of still living peoples of the areas concerned.

Ayten Aydin

Civil Engineer/Anthropologist*

a.aydin@alice.it

* Former UN/FAO Senior Policy & Program Adviser