Fractal Geometry in African Material Culture

Dr. Ron Eglash
Center for the Humanities
Oregon State University
Corvallis OR 97333-4506

While my mathematical work describing the presence of fractal shapes in African architecture is quite orthodox, its social significance invites a variety of misinterpretations. On one hand, those of the 'zen physics' persuasion will see this as proof of an abstract, mystical intuition of the non-west -- thus supporting the essentialist stereotypes of orientalism. On the other hand, those who romanticize the 'eco-native' will see this as evidence for a concrete, unconscious expression of oneness with nature -- thus supporting the colonial construction of primitivism. My own approach is based on fractal geometry as a conscious, artificial construct in African societies, that is, as an indigenous knowledge system or technology. The methodology and theory behind such an approach has become well established in the recently developed discipline of ethnomathematics (Ascher 1991, D'Ambrosio 1985, Gerdes 1985, Crowe 1988, Zaslavesky 1973).

1) Fractals in African Material Culture

In north Africa fractals are associated with the feedback of the "arabesque" artistic form, particularly in the branches of branches forming city streets. In central Africa it can be seen in additive rectangular wall formations, and in west Africa we see circular swirls of circular houses and granaries. These structures are distinctly fractal in appearance and can be easily simulated by fractal geometric methods (e.g. figure 1, the settlement of Mokoulek in Cameroon). The fractal structure of African settlement patterns was confirmed by dimensional measure of digitized photos in Eglash and Broadwell (1989).

The cultural semantics of these architectural forms show that they are not merely a consequence of unconscious spatial optimization. Rather, concepts of scaling, recursion, and even infinity are symbolically linked to these material structures in close parallel to their usage in the western context of fractal geometry. This is by no means limited to architecture. Recursion, for example, can also be seen in many African art forms. Ethiopian crosses and ancient Egyptian cosmological icons use it to express religious ideas. In the Cameroonian bronze work we see it as a visualization of prestige (including a wonderful example of self-reference: a figure of the king smoking his royal pipe; the bowl of which is a figure of the king smoking his pipe, the bowl of which...). Fulani wedding blankets use scaling iterations to map an animist energy flow. Many other examples express fecundity, fertility, and unending health or well-being through the unending recursion of fractal forms.

Specific scaling techniques are particularly evident in Ghana, where the use of log spirals to represent self-organizing systems (biological morphogenesis and fluid turbulence) is common. Expansion/contraction of spatial form is also common in the textiles of this area, and again shows conscious use of this concept.

Symbolic mathematics in Africa also involves fractal concepts. Numeric scaling sequences, particularly doubling, can be seen in notational, gestural and linguistic counting systems. Doubling is used to model the forked patterns of lightning in the Shango religion, and can be seen in the mathematical records of ancient Egypt, where it was used for multiplication and division. Binary recursion is used in Bambara sand divination. The stylized snake symbol is used to depict feedback processes as the essence of morphogenesis in environmental, biological, and chemical systems, as well as in making the associations of recursion with infinity (e.g. the snake as symbol of eternal health or prosperity, as well as cosmological infinities). It may also have been the source for the infinity sign invented by cryptographer John Wallis in 1655; which brings us to the second area of this study.

2) Africa in the history of fractals

Recursive scaling in Egyptian temples can be viewed as a formalized version of the fractal architecture found elsewhere in Africa, and is most significant in its use of the Fibonacci sequence (Badawy 1965; see Petruso 1985 for additional Egyptian use of the sequence). The sequence is named for Leonardo Fibonacci (ca. 1175-1250), who is also associated with an unusual example of recursive architecture in Europe (Schroeder 1991, pg 85). Since Fibonacci was sent to North Africa as a boy, and devoted his years there to mathematics education, it is possible that this seminal example of recursive scaling is of African origin.

Benoit Mandelbrot, the "father of fractal geometry," reports that his invention is the result of combining the abstract mathematics of Georg Cantor with the empirical studies of H. E. Hurst. Cantor was a 19th century Rosicrucian mystic, who often combined his mathematics with his religious belief. His cousin Moritz Cantor was a famous scholar in the geometry of Egyptian art and architecture. Given these facts, and the similarity of this first European fractal to the Egyptian architectural structure symbolizing recursive autogenesis, an Egyptian origin is likely here as well.

H.E. Hurst was a British civil servant who lived in Cairo for 62 years. It was only because of the data set provided by the Cairo nilometer that Hurst was about to deduce the scaling law which Mandelbrot used to bring Cantor's abstract set theory into empirical practice; thus Hurst's work can be viewed as a direct outcome of this African tradition of searching for frequency domain patterns.

Does the characterization of euclidian versus fractal become yet another self/other dualism, or, as suggested by Gilroy (1993), can the properties of fractals themselves be used to displace such binaries? The boundary between self and other becomes quite different if we conceive of it as a fractal; and the diasporic history of African culture could be said to constitute such an example (c.f. Phillips 1990). Also unresolved are

Foucaultian structural questions. In colonial discourse, for example, the "chaotic" settlement patterns of Africans are clearly used as proof of inferiority. But colonialism also made use of the self-organizing aspects of African society, and valorized their "more natural" ways of living. Conversely, while there are many examples of how Africans have benefited from decentralized social processes, there are also instances where such self-organization becomes self-exploitation (c.f.. the voluntary caste system described in Stoller (1988)). How can we differentiate between these two effects, and what are the implications for the formulation of concepts like "autonomy?"

In summary, the new formulations of chaos and order in science are potent agents for cultural change, and it is at the intersections of the humanities and sciences where we are likely to find the most promising kinds of turbulence. Fractal geometry in African culture provides a particularly useful focus for such inquiry, while supporting questions of wider import in many areas.

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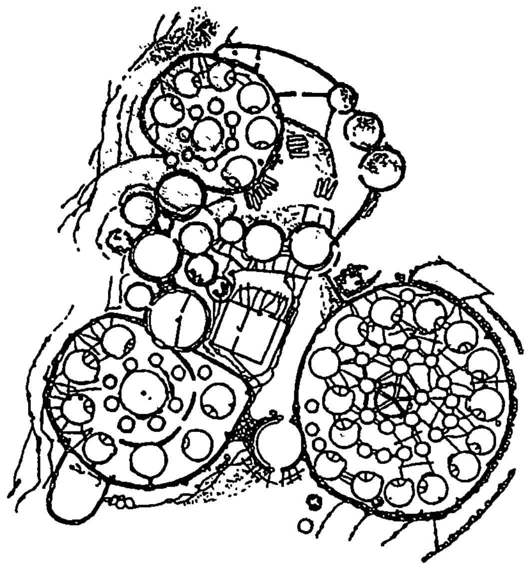
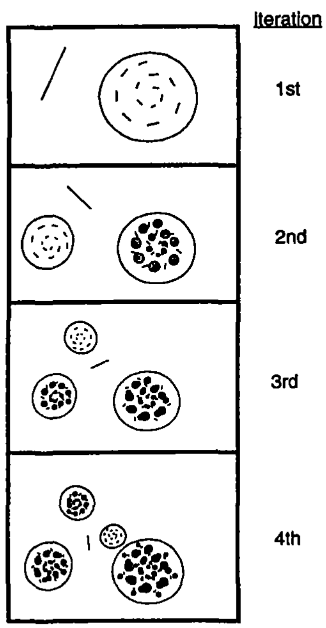
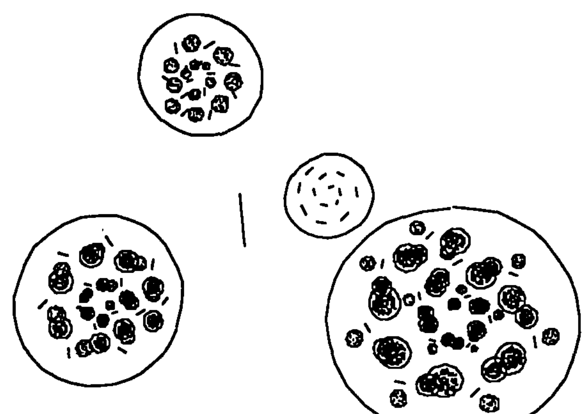
Figure 1: Mokoulek settlement diagram



architectural diagram for Mokoulek



fractal generation



enlarged view of fourth iteration