Projecting Images of Complex Systems

– that can be explored analytically –
Combining Two Exploratory Paradigms for Perspective

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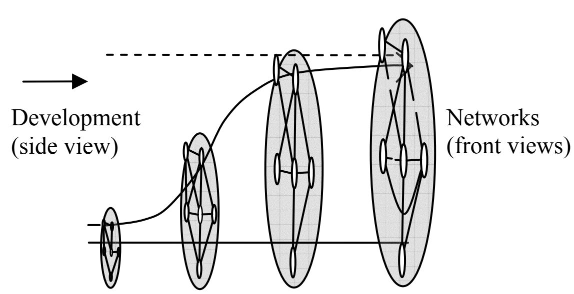
Abstract

When natural systems are thought of as following formulas, scientific models are built as sets of equations. Then adjusting equations to fit the data curves obtained from measurements are the guide to designing models for how nature is interpreted as working. Now that natural systems are being considered as evolving original designs of nature, their forms can no longer be faithfully represented by the fit of their data to fixed formulas. The question arises how to measure them. There appear to be at least two effective and closely related ways, each involving a method of projecting a complex image directly from the complex subject, that results in a derived object amenable to analysis. These two are, reading systems as ***whole events*** *from beginning to end analyzing their their developmental continuities (growth processes), and projecting planes of* ***internal networks*** *of relationships (cellular structures).*

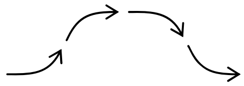
Neither of these directly translates into sets of rules like those used in building complex system models of the present common forms. Both methods, though, do provide frameworks for representing whole complex systems with high degrees of comparable variety to the original natural subject. This then helps provide a standard against which a model may be compared of higher quality than has been previously available, as well as direct suggestions of true behavioral features that models might be designed to emulate and judged against..

1. Introduction

Switching back and forth between different points of view, such as looking at a physical object from both front and side, is useful for the perspective it gives, and the way it informs an observer of the whole shape. For a better view one can then alternate between looking at systems as **a process of change,** from beginning to end, and as **a series of structures**. When projected from an original natural physical system, with methods that maximize the quality of information not influenced by the process of image making, it produces useful new perspectives for both understanding and analysis. Switching back and forth between process and structure views of physical systems might take many forms. This research note is on one pair of methods that both seem to work and coordinate well, and serve to identify a major class of complex systems, the ones that emerge by growth. The developmental phase view (process of change) is like a **'side view'** and a relationship network view (structures) a **'cross section'** view usually represented **as the 'front view'**, the two having orthogonal relationships.

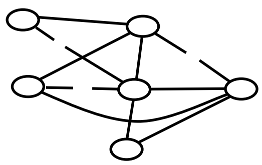


Process of Changing Structures



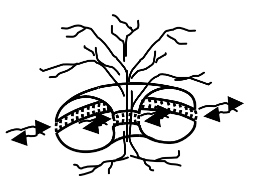
Whole Events

The developmental phase view can be graphically represented as a 'bump on a curve', a series of periods of time during which a complex system acts as a whole, proceeding through a series of 4 organizational feedback reversals, reflected in the shapes of time series measures. The analysis of the shifting derivative continuities of the measures leads to exploring the changing properties of the evolving networks of relationships that exist during each phase. The reason it is a true image of a whole natural system is that it traces a continuity of change from beginning to end, and offers many avenues to explore the original subject in it's greater complexity in a single extendable model.



Network Cells

The network view of complex systems is a cross section of the evolutionary phase view, and depicts the state of the system at a given time as a network cell of nodes and links mapping a plane of relations in the physical system. The analysis of the properties of networks lead to observations of the processes by which they evolved and change, such as the 'scale free' distribution of connectedness associated with the process of elaboration and refinement. Network models offer faithful images whole natural systems when they are built by exhausting the domain of the subject for relationships of the kind being mapped, to produce an image of the whole cell of relationships from one perspective by a natural process.



Whole System

A more comprehensive, if also more symbolic, model of the complex organization of natural systems represents them as a toroid of evolving networks on different planes of relationships integrated with each other and through open mediums of exchange, like a tree. What makes the analysis of properties projected from a whole system meaningful is that it gives you path into studying the whole in its greater generality, a window. That this major class of systems are individuals in both time and space, is probably the most useful observation that can be made. Effective observation also involves noticing how they intermingle with each other, like plants producing compost, a highly complex kind of relationship between systems that is quite fundamental to developing the environments in which new individual systems and system events evolve.

2. Analysis of Networks

Network Science is a relatively new addition to the wide array of complex systems sciences, having had it's sixth conference this May. The papers in the field explore diverse questions: visualization, topology, and evolution, case studies, among others. One thing that caught my attention, was the high concentration of 'missplaced physicists' in the group, people thinking physics and having jobs in nearly any other field. The kinds of networks being studied as whole complex natural systems include the protein bindings of life, and the econonic product knowledge communities of the world. The conference website has links to many of the web sites. [4]

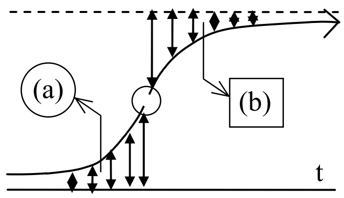
The specific methodologies to distinguish the study of networks projected as planes of relationships from individual complex natural systems, and the study of hypothetical networks built for pure research or modeling, etc. are not developed yet. The marvelous work being done hopefully indicates that that will be on the way. The methodologies demonstrated are clearly advanced and I am only proposing that people look around at what they are really studying and understand the marvelous features of well constructed networks that provide true complex images of true complex systems, **a measure of organization** deriving 'planes' of relationships by applying a natural category to **a self-defining subject**.

3 Analysis of Whole Events

3.1 Continuity What makes it possible to study process events in time with continually changing organization is the continuity of their changes. Change requires a process and that is reflected in measures of change as a flowing shape. Natural continuity is like derivative continuity in functions, except that the 'function' is new at every point, and continually evolves. Natural continuity is more complex than equations and the key to learning from it is to have analytical methods that reveal the changing shapes of the flows without distortion, and then using those subtle shapes as indicators to direct attention back to understanding what's happening in the subject. The indications of evolving shape are lost by representing them with non-evolving formulas.

A corollary of the conservation of energy [1] is that the beginning or end of any energy flow needs to occur by a developmental process (i.e. not have infinite derivative rates of change). The evidence appears to bear this out for organization as well, with the turning points of developmental change corresponding to structural change in the animating instabilities of its networks of relationships. This helps an observer note where and when structural change occurs and learn what features of nature models might try to emulate.

3.2 Simple Emergence



A SUCCESSION OF SYSTEMS

Each arrow of the figure represents a new level of organiztion in the series of networks of relationships in a evolving system. The circle in the middle is where to look for the feedback switch. A good example for how to use it as an observation tool is to trace your own design process for some project. You might consider the process of designing a computer model, represented as an event in time, as a whole process of developments from beginning to end. Designing a complex system model starts with an idea for a kind of game and a first simple diagram of how it would work. If you think of each stage you discover a sequence of distinctly different 'ways of working' ending in refinement. You can diagram these as separate networks of relationships. What you find you need for keeping track of it all is a frame of reference that refers to every part of the process, a continuous measure..

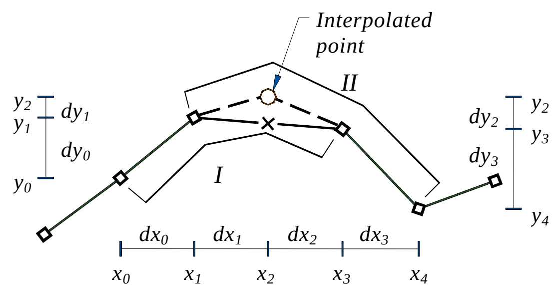
The simple reason for looking for growth curves and carefully studying their inflection points is that growth is beginning, and the markers let you know when and where to look for how and why things are beginning. Decay is ending, and the transition from one to the other is an important transformation in the structure of the networks of the evolving system.

before → | ? |→	after	- question	a.
before → | f(x) |→	after	- equation	b.
before → | ∽ |→	after	- process	c.

Thinking about it as a process raises more questions. Each kind of natural system, like societies, ecologies, organisms, businesses, storms or chemical or electrical events, display different kinds of inventive history dependent continuities, that can be much better understood by tracing a single measure of their changes as a pointer to their internal switches from beginning to end.

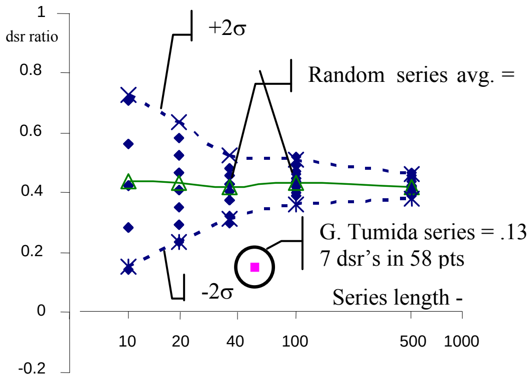
3.3 Eventfulness What seems to be missing from scientific control theory is the eventfulness seen throughout nature. Control theory is all about how things that appear to happen spontaneously are actually determined by something else. Maybe this is a holdover from reading nature as following our formulas for guidance and not just us. The shape of any segment of any formula predicts all other values. Complex systems, though, ***discover*** their opportunities as much as they are ***driven*** by their necessities. A growth process is a truly out-of-control behavioral eruption, having no immediate limit of any kind, freely blowing up it's little part of the open environments in which it's particular piece of genius took hold, taking a flier and hurling itself at the infinite. Sometime later it finds it's not. This is evident in how it only responds to it's limits when it hits them. Growth begins out of contact with its limits. Where it discovers it's limits is where the inflection point occurs, a real event. Eventfulness is the key to reading markers of change. It won't be easy to model, but seems like it needs to be the main subject of model making.

3.4 Derivative Reconstruction For some data the better way to reveal the complex flowing behavioral shapes of the data is to use a smoothing 'kernel' with a hole in the middle. Bracketing points to use 3rd derivative interpolation of a point from the slopes on either side is a particularly sensitive way to minimize the higher derivative noise in a series without changing the shape of the curve.



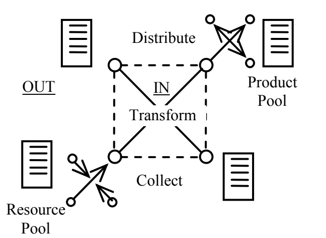
This tool helped precisely locate the inflection points in New York City systemic community response to the 80's crack epidemic to time the event supression in the low crime communities 5 years before it reached its peak in the high crime communities. It lets you closely watch things happen.

3.5 Testing for Flow Complex continuous fluctuation in data looks just like noise, but that actually hides a depth of fine detail in the evolving complex behavior of systems that can be partly revealed. That can be done by carefully varying the degree on noise suppression to see when the continuity of the series jumps. The continuity of a series can be measured as the number of double reversals in direction in its slopes. Smoothing does improve the continuity of random fluctuation as well, but the improvement is sluggish, and doesn't jump.



This method helped expose a series of eruptive evolutionary events in an punctuated speciation event that was previously determined to be a random walk and dismissed as uninformative [3].

4. Throughput models



The more traditional complex system models developed from the examples of economies, organisms and ecologies attempt a more difficult task than the 'Whole Event' or 'Internal Network' projection methods of studying complex systems. Lots of good work has been done on them, but they get weighed down by the very complexity of the task required, and tend to leave big things out (like eventfulness). They try to describe systems in total representing all their internal relationships embedded in a larger open system. That is, of course, correct, but just very hard to imagine and impossible to model.

5. Case Studies

see http://www.synapse9.com/
http://www.synapse9.com/drpage.htm#basics

6. References

[1] 1995 Reconstructing the Physical Continuity of Events
http://www.synapse9.com/ContPrinciple.pdf

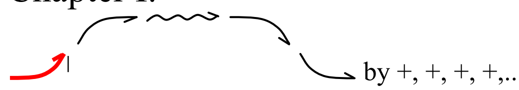
[2] 1999. Features of Derivative Continuity in Shape. (IJPRAI), V13 No 8 1999 1181-1199 M. A. Rodrigues ed., Invariants for Pattern Recognition and Classification.

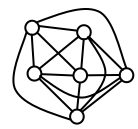
[3] In review Flowing processes in a punctuated species change, G. pleisotumida to G. tumida, display ing feedback driven evolution,

[4] NetSci-07 conference May 2007
http://www.nd.edu/~netsci/conference.html

Chapters of a whole story of a complex system seen as a whole series of evolving networks of relationships

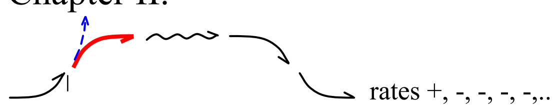
Chapter I.

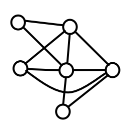




interior networks elaborate,
uniform distribution of connectedness
(1) expansion free of limits

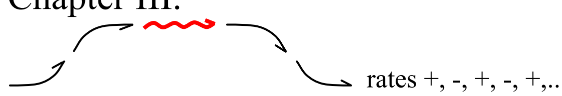
Chapter II.

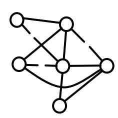




interior networks refine (or destabilize)
inverse sq. distributed connectedness (1)
expansion responding to limits

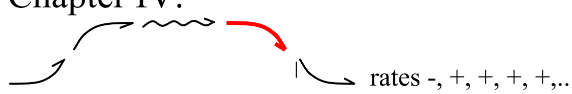
Chapter III.

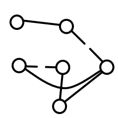




adaptation, maintenance, 'homeostasis'
connections into other networks expand
integrating with environments

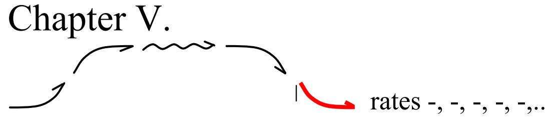
Chapter IV.

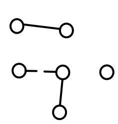




network disintegrates
unknown statistical features
internal & external connections break

Chapter V.





network decays
unknown statistical features
remains retain evolved links, 'compost'