

Complexity & Postmodernism

Understanding Complex Systems

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Chapter 1

Approaching Complexity

Some systems have a very large number of components and perform sophisticated tasks, but in a way that can be analysed (in the full sense of the word) accurately. Such a system is complicated. Other systems are constituted by such intricate sets of non-linear relationships and feedback loops that only certain aspects of them can be analysed at a time. Moreover, these analyses would always cause distortions. Systems of this kind are complex.

Complex systems are usually associated with living things:

- 1) Complex systems consist of large number of elements
- 2) The elements have to interact
- 3) The interaction is fairly rich, i.e. any element in the system influences, and is influenced by, quite a few other ones.
- 4) The interactions are non-linear
- 5) The interactions usually have a fairly short range
- 6) There are loops in the interactions. The effect of any activity can feed back onto itself, sometimes directly, sometimes after a number of intervening stages.
- 7) Complex system are usually open systems
- 8) Complex systems operate under conditions far from equilibrium.
- 9) Complex systems have a history
- 10) Each element in the system is ignorant of the behaviour of the system as a whole, it responds only to information that is available to it locally.

The second law of thermodynamics, which states that the entropy of a system can only increase. Entropy can be seen as a measure of the 'disorder' in a system. As a system transforms energy, less and less of it remains in a usable form, and the disorder in the system increases.

Claude Shannon use it as a measure for the information in the content of a message.

By replacing 'energy' with 'information' in the equations of thermodynamics, he could show that the amount of information in a message is equal to its 'entropy'.

The entropy theory of information does, however, have a problematic implication: if information equals entropy, then the message with the highest information content is one that is completely random.

A complex system cannot be reduced to a collection of its basic constituents, not because the system is not constituted by them, but because too much of the relational information gets lost in the process.

Representing information

In order to respond appropriately to its environment, a complex system must be able to gather information about the environment and store it for future use.

Meaning is conferred not by a one to one correspondence of a symbol with some external concept or object, but by the relationships between the structural components of the system itself.

Self organisation

A complex system, such as a living organism or a growing economy, has to develop its structure and be able to adapt that structure in order to cope with changes in the environment.

Connectionist models

Each neuron can be seen as a simple processor that calculates the sum of all its inputs, and, should this sum exceed a certain threshold, it generates an output.

- 1) A closer look at the characteristics of complex systems clearly shows the limitations of the analytical method when dealing with complexity.
- 2) Algorithmic and information theoretical approaches to complexity fail in their attempts to reveal the true nature of complexity. Complexity is incompressible. Since the model will have to be as complex as the system it models, it cannot reveal the 'true nature' of the system in terms of a few logical principles.

Chapter 2

Introducing Connectionism

Make a system which is 'soft' at bottom complex enough that hardness will sometimes appear when viewed at a higher level.

A system that does not function on the basis of rules, but where certain systematic properties can be described by means of rules if they prove to be useful.

To think in terms of relationships, rather than in terms of deterministic rules, is not a novelty for science, but it has always been seen as part of qualitative descriptions and not as part of the quantitative descriptions and calculations deemed necessary ever since Kepler's insistence that 'to measure is to know'.

Many phenomena, especially in the life-sciences, but also in physics and mathematics, simply cannot be understood properly in terms of deterministic, rule based or statistical processes.

Chapter 6

Self-organisation in complex systems

The notion of 'structure' pertains to the internal mechanism developed by the system to receive, encode, transform and store information on the one hand, and to react to such information by some form of output on the other.

Structure is neither a passive reflection of the outside, nor a result of active, pre-programmed internal factors, but the result of a complex interaction between the environment, the present state of the system and the history of the system.

KEY ASPECTS

The capacity for self-organisation is a property of complex systems which enables them to develop or change internal structure spontaneously and adaptively in order to cope with, or manipulate, their environment.

ATTRIBUTES OF SELF-ORGANISING SYSTEMS

- 1) The structure of the system is not the result of an a priori design, nor is it determined directly by external conditions. It is a result of interaction between the system and its environment.
- 2) Self-organisation is not merely the result of processes like feedback or regulation that can be described linearly. It involves higher-order, non-linear processes that cannot be modelled by sets of linear differential equations.
- 3) Self-organising systems increase in complexity. Since they have to 'learn' from experience, they have to 'remember' previously encountered situations and compare them with new ones. If more 'previous information' can be stored, the system will be able to make better comparisons.
- 4) A self-organising system therefore always has a history. Information that is not used simply fades away. This process not only creates space in memory, but, more importantly, it provides a measure of the significance of the stored pattern. The more something is used, the stronger its 'representation' memory will be.

In a nutshell, the process of self-organisation in complex systems works in the following way. Clusters of information from the external world flow into the system. This information will influence the interaction of some of the components in the system – it will alter the values of the weights in that 'represents' that cluster, i.e. a certain pattern of activity will be caused in the system each time that specific cluster is present. If two cluster are regularly present together, the system will automatically develop an association between the two. For example, if certain state of affairs regularly causes harm to the system. The system will associate that condition with harm without having to

know beforehand that the condition is harmful. As the system encounters different conditions in the environment, it will generate new structures to 'represent' those conditions, within the constraints determined by the amount of memory available to the system.

Since the most important aspect of self-organisation is the emergence of structure through the activity of microscopic units that do not have access to global patterns, the principles that determine the behaviours of weights and nodes locally are very important. The following list provides a number of preconditions for self-organisation in any system and they are fundamental to the understanding thereof.

- 1) The system consists of a large number of microscopic elements or units that are relatively undifferentiated initially.
- 2) The strengths of interconnections change as a result of local information only.
- 3) There is competition among the units.
- 4) There is also co-operation among at least some units.
- 5) The interactions among units have to be non-linear.
- 6) At last, and a most important, principle requires that the memory of the system be stored in a distributed fashion.

Self-Organised Criticality

A self-organising system will try to balance itself at a critical point between rigid order and chaos.

With the system poised at the point of criticality, the number of stable states will not only be optimised, but the system will also be able to change its state with the least amount of effort.

ORGANISATION THROUGH SELECTION

To be able to interpret its environment, the system must have at least the following two attributes: some form of resistance to change, and some mechanism for comparing different conditions in order to determine whether there has been enough change to warrant some response. Both these attributes merely translate into the need for a form of memory-without resistance to change, memory is impossible.

Under certain critical conditions there may not be enough time or margin for error to allow an adaptive response, and predetermined 'hard-wired' reactions may be the only solution.

This indicates a need for some form of balance between the two extremes. But where does this balance lie? How much is genetically encoded and how much can be ascribed to responses to the environment?

Fortunately, the need to indicate precisely where the balance lie becomes less pressing if we can show that the same mechanisms implement both the predetermined and adaptive needs of the system.

Neural group selection

We can summarise the model in the following general terms. The brain is pre-structured in a way that is general and non-specific, but with enough differentiation (i.e. enough asymmetry) to allow external influences a 'foothold'. The 'general' structure is then modified through experience and behaviour in order to reflect the specific circumstances encountered in the history of the organism in question. The brain thus organises itself so as to cope with its environment. Note that certain parts of the primary repertoire could be permanently 'hard-wired', and will therefore not be changed by experience. This enables the organism to transfer certain capabilities to its offspring genetically.