Structure evolution: from chaos to ordered states

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Abstract: - The concept of knowledge involves those domains where an order has been established. Order was created by prevalent, repetitive stimuli acting on articulated structures located within the domain. These stimuli can be of different nature, for example astronomical, biological or climatic. Within a domain the prevalence of environmental stimulation generates only certain aggregated, integrated structures and not others. In the domain where man is confined (as well as in other domains), order springs out of the initial chaos of the universe.
A model is herein proposed for the process generating order from disorder and the boundaries for the structure state classification when a pre-defined resolving power is adopted are outlined.

Key-Words: Global interaction, Structure evolution, Environmental stimulation

1 Introduction

All of the components of our world "speak" with one another. This interaction involves a similarity imprimatur, producing the genesis of aggregate structures that easily exchange messages through "privileged" channels created by the frequent exchanges of repeated messages. In this way, "domains" are built where the features of stimuli and messages averagely received show very slow variations. The "size" of a domain is connected to the resolving power adopted in observing events. Common examples of domains are the earth and solar system or the earth surface.
The messages averagely present are assumed as environmental stimuli. They induce modifications to a structure state defined by a proper sequence of parameters (state vector). These stimuli change very slowly if compared to the time changes recorded in the states of a domain's aggregate structures.

2 Global interaction

A domain-confined structure is subject to stimuli coming from sources in domains where, as previously said, modifications happen very slowly if compared to changes in the structure itself [5], [6], [7]. Apart from environmental stimuli due to external or remote sources, an object also receives casual or programmed stimuli (for example hammer hits or electric shocks). Such stimuli can be predictable, if caused by environmental sequential genesis, or unpredictable, when caused by fortuitous events or generated by external domains.

As shown in Fig. 1, the stimuli averagely present in a domain lead a structure to shift from one state to another, privileging some states and excluding others. This is in contrast with Gaussian statistics which frequently turns wrong when applied in these cases [2], [3]. An example is the domain where man is confined, where a "population" of elementary particles can be observed, such as protons, electrons, mesons, etc. all having the same masses and charges. In other domains the population might mostly consist of antiprotons, positive electrons, etc., since prevalent stimuli are different.

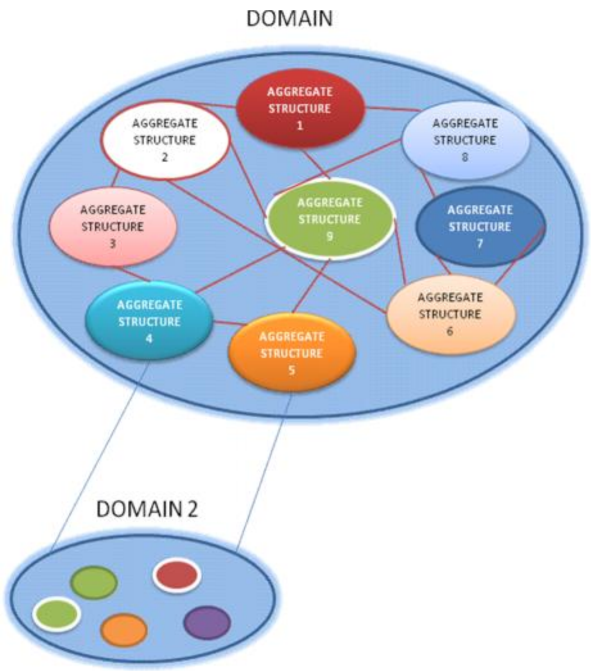

Fig. 1 - Schematic representation of a domain containing aggregate structures (or organisms) whose state is modified by external stimulation. The actual structure state can be defined by a parameter sequence (state vector).

3 The meaning of knowledge

In those domains where an order is implemented knowledge allows to foresee the evolution of a structure within a given T time. Evolution involves a sequence of states through which one structure's configuration is modified within its own domain, assuming as known the initial state detected by a measurement process of time duration $\Delta T << T$. This is possible if environmental stimuli are not subject to significant variations during pre-established periods and, hence, the specific system evolution is caused by repetitive, non-randomly variable stimuli.

Knowledge, as far as it has been established, is not the property of one individual alone but of the whole community of interacting individuals. In the same way, once individual computers are connected they form an interlaced network with more possibilities of correlating acquired data and predicting data evolution. A network of similar interconnected PCs able to talk to each other is a unique calculation tool much more powerful than one single PC.

4 The model proposed to foresee structure evolution

The evolution or mutation of an object occurs under the action of repeated stimuli that can either be artificial, or come from the environment, or be originated by the object's domain. Stimuli are translated into operators that act on the state vector whose parameter changes describe the object's evolution. If the possible states of a structure are countable (i.e. they are not a continuum) the impact of stimuli can be represented by means of a matrix acting on the state vector D, once, twice, and so on up to N times. The corresponding mathematical formula is as follows [1]:

$$A|D_0> = D_1> \qquad [A]^N|D_0> = |D_N>$$

The repetitive process $(N \to \infty)$ is the mechanism causing the genesis of aggregate, ordered structures within a domain by privileging some and excluding others. In this process an important role is played by entropy, which is defined as:

$$S = -\sum P_\alpha \log(P_\alpha),$$

where P_α is the probability to obtain the α state. In a single domain, entropy can also decrease, as affirmed by Schrödinger ("Entropy, as far as the world observed increases, increases, though locally entropy can decrease").

If the genesis of a structure is defined by a continuous representation, the evolution process can be described by a differential equation system with n variables x_1 x_2 … x_n, where the x values are the parameters of the state vector. The initial conditions x_{10}, x_{20} … x_{n0} define the vector of the initial state; any constants appearing in the equations represent environmental stimuli.

In order to describe the genesis of objects from initial conditions, it is necessary to define the parameters necessary to "interpret" the environmental stimuli in the given domain, which

means either the constants present in a differential equation in the continuous case, or the parameters of a matrix in the discrete case, or also the best calculation process.
The higher the resolving power of the detecting tool used is and the longer the observation time, the more accurate the detection of initial conditions will be. In any case, an inconvenience that cannot be eliminated during the previous detecting process is the effect of the measurement process itself, which produces stimulation in the structure and consequently modifies its state vector, as reported in [4]. The greater the resolving power of the detecting system, the more prolonged in time this stimulus will be.
The parameters of a state vector must be conveniently established to identify which of them can be considered as constants during the phenomenon without resolving power degradations and which ones have to be considered as variables.
The calculation process involved is particularly difficult, since most of the stimuli present in nature necessarily require a representation with non-linear operators.

5 How evolution privileges only some configurations

The action of repetitive stimuli within a domain leads its aggregated structures to take on certain privileged configurations, characterized either by oscillations among different states or by permanence of the object in a specific state, which is maintained until changes occur in the present stimuli. Regardless of initial conditions, some configurations just do not occur, while others tend to appear again and again.
In astronomy, the earth revolution around the sun is a typical example of oscillation among a continuum of states (the orbit) of a system subject to repetitive stimuli such as gravity and the inertia principle.
In zoology, the presence of man on earth is a typical result of the stimuli exerted by the planet's environmental conditions (e.g. the presence of water) that led the human being to take on a particular configuration with the exclusion of others, such as reaching the height of a skyscraper.
In botany, the green color of the leaves of most plants is a result of specific environmental conditions (earth atmosphere allowing only part of solar radiation to pass through) and a number of light absorption properties.
In electronics, the multitude of low power architectures is a result of the stimuli of the great diffusion of battery apparatuses and silicon peculiar thermal properties.

6 An example

An example which shows the consequences of a prevalent interaction in a domain in privileging only some configurations of aggregated structures is the game card repeated distribution program (Fig. 2). In this software, by redistributing and reordering the cards, gamers are subject to what can be seen as an environmental continuative, repetitive stimulus acting within the domain.
A card pack with four suits (hearts, diamonds, clubs and spades) and a number of cards varying from 1 to 99 is distributed to 4 gamers (called west, north, east and south, as in bridge). Each gamer's hand consists of a number of cards equal to the number of cards per suit (from 1 to 99). The cards are grouped by each gamer according to suit. Pushing the distribution button, from west to south, the hand of each gamer is redistributed without mixing and a new grouping according to suit is done.
Taking as example the first diagram in Fig. 3, the only card of clubs of west is given back to west himself, the 5 five diamonds cards are given in sequence to north, east, south, again to west and again to north and so on, continuing from west to north, east and finally south, until, after the grouping according to suit, the distribution of the second diagram in Fig. 3 is obtained. If the redistribution is repeated more times, it is easy to see that the cards distribution tends to converge towards a stationary state, oscillating among a number of states or taking on a fixed configuration.
In Fig. 3, a typical case of configuration sequences with 13 cards per suit is shown.

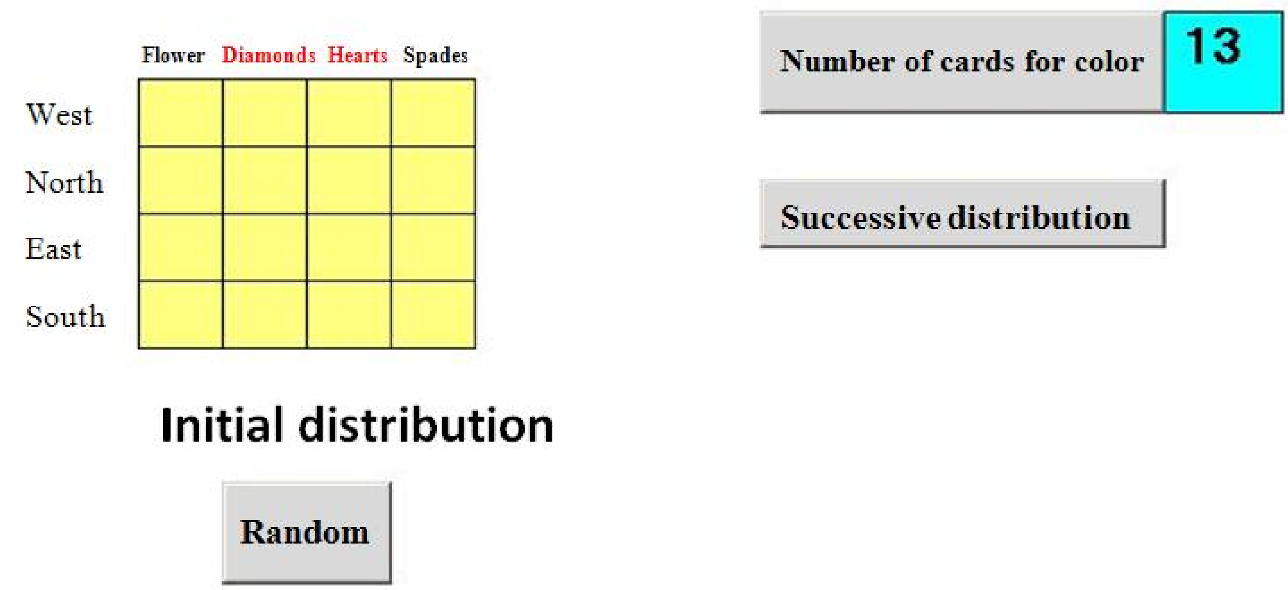

Fig. 2 – An example of a card game to illustrate the method proposed.

The configurations were grouped by row from left to right and in the columns equal distributions appear, so as to highlight repetitiveness. After the first redistribution, the system has the same configuration as after the fifth, after the second it has the same configuration as after the sixth, and so on. Every four redistributions, the system returns to the same configuration.

It is easy to observe that the system converges rapidly towards a situation oscillating among 4 configurations, a typical case with this number of cards per suit. The initial random distribution is rapidly excluded by the action of the repetitive stimulus.

A slightly different situation arises if 17 cards per suit are used, as shown in Figure 4.

In this case, after two redistribution sequences the system assumes a fixed configuration, which does not vary if the stimulus is maintained. The configuration cannot be modified with a redistribution.

The above examples lead to the conclusion that this software is a good example to illustrate how repetitive stimuli in a domain lead its structures to take on well-defined, stable configurations and to exclude others.

	Flower	Diamonds	Hearts	Spades
West	1	5	4	3
North	3	4	5	1
East	1	3	2	7
South	8	1	2	2

	Flower	Diamonds	Hearts	Spades
West	3	3	4	3
North	3	4	3	3
East	4	2	3	4
South	3	4	3	3

	Flower	Diamonds	Hearts	Spades
West	3	3	4	3
North	4	3	3	3
East	3	3	4	3
South	3	4	2	4

	Flower	Diamonds	Hearts	Spades
West	4	2	3	4
North	3	4	3	3
East	3	3	4	3
South	3	4	3	3

	Flower	Diamonds	Hearts	Spades
West	3	3	4	3
North	3	4	2	4
East	3	3	4	3
South	4	3	3	3

	Flower	Diamonds	Hearts	Spades
West	3	3	4	3
North	3	4	3	3
East	4	2	3	4
South	3	4	3	3

	Flower	Diamonds	Hearts	Spades
West	3	3	4	3
North	4	3	3	3
East	3	3	4	3
South	3	4	2	4

	Flower	Diamonds	Hearts	Spades
West	4	2	3	4
North	3	4	3	3
East	3	3	4	3
South	3	4	3	3

	Flower	Diamonds	Hearts	Spades
West	3	3	4	3
North	3	4	2	4
East	3	3	4	3
South	4	3	3	3

Fig. 3 – Card distributions converging to well-defined configurations.

	Flower	Diamonds	Hearts	Spades
West	4	5	2	6
North	3	5	3	6
East	5	3	7	2
South	5	4	5	3

	Flower	Diamonds	Hearts	Spades
West	3	6	4	4
North	4	4	4	5
East	5	3	5	4
South	5	4	4	4

	Flower	Diamonds	Hearts	Spades
West	4	5	4	4
North	4	4	4	5
East	5	3	5	4
South	4	5	4	4

Fig. 4 – Another card game example.

7 The modification of stimuli in a domain

The prolonged action of stimuli, as previously shown, leads the system to converge towards either a well-defined state or an alternation of limited states.
In the equations describing the genesis of microstructures ("micro" when compared to a domain's size) the constants (e.g. the matrix coefficients) are subject to mutations which are often slow, but at times so traumatic to change the genesis characteristics.
Whenever stimuli undergo mutations, usually induced by agents outside the domain, the state of the system can also undergo a mutation whose speed and consistency may vary according to the entity of the stimulus variation and the continuity of the new stimulus.

8 Conclusions

The method herein proposed to predict a structure's evolution demonstrated that likeliness imprimatur among structures depends on both the concept of domain and the mechanism by which the repetitive action of stimuli leads the domain's objects to take on certain configurations and not others.
Stimuli variations can also be caused by variations in humankind's knowledge, giving rise to new scientific discoveries and innovative technological solutions. For example, climate change has engendered research developments in solar cells with the discovery of new organic solar cells, as well as a renewed interest in nuclear energy.

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