Cultural Evolution as a Knowledge-Base for the Modeling and Simulation of Socio-Ecological Systems

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Abstract

A modeling supra-strategy for socio-ecological systems is suggested, based on the top-down observation that in many high information-viscosity systems (including Biological ones), an enfolding system 'relegates decision-authority' for the entire system, concerning a self delineated range of sub-systems (contexts), to an 'Inner World' - to one of its sub-systems; thus, a model may be a replication of such an 'Inner World'. Consequently, it does not have to process the entire amount of information (which constitutes a system's structural complexity), but to filter and compile only a fraction of the fraction, deemed relevant by the real-world system's 'Inner World'.

Some of the necessary modifications to Complex Systems methodology, which are required for adopting such a modeling strategy, are discussed; these are:

The addition of a top down view, resulting in a taxonomy of systems according to the tendency for making new structures/information emerge;

The interpretation of CS dynamics as expansion and contraction in the amount of information (as discrete changes in structural and/or dynamic complexity);

Semantics (reduced to the choice of a future-strategy) is viewed as necessarily local - different for any and all 'Information areas' of a system.

1. The Study of Socio-Ecological Systems within the CS Framework

The ability to analyze, simulate and eventually possibly manipulate socio-ecological systems - discerned as being driven forward in time by human decisions, taken together as collectives of culture-partners and employing networks of human-human interfaces, thus undergoing at all times a cultural evolution - has always been one of the central aims of the study of complex systems.

Lately, in the wake of the failure of traditional Economics to contribute to our understanding of the current financial crisis, efforts to emulate (thus figure out a dynamics for) socio-ecological systems have gained some urgency. Thus, the 24/07/09 issue of *Science* devoted a whole issue to networks of human interfaces, under the title: "Complex Systems and Networks"; containing the lead: "Ourselves and Our Interactions: The Ultimate Physics Problem?" and papers like: "Economic Networks: The New Challenges" or "Predicting the Behavior of Techno-Social Systems" and the like.

In order to keep a check on the number of interconnected issues that human-human networks raise, my own work (concerning spatio-cultural evolution) is limited a-priori to actual actions resulting in an actual measurable change in the environment and/or in a community's actual location. People's mind-activity: thoughts, intentions, planning and so forth, are kept out and so is the connection between intent and action. Furthermore, it is limited to what people *do together* as an ad-hoc grouping - a collective, as they form this group concerning a certain self demarcated range/variety of actions (a context); division of labor within the group, as well as the division of decision-authority among its members, are also outside the scope of this discussion.[1]

Within the framework of CS theory, one attempts to make models which are blue-prints for adequate simulations - adequate meaning that such programs 'behave' according to a saticefycingly similar dynamics, compared to that of the subject socio-ecological system, e.g. a component of a city. Such a program provides an analysis of a kind by emulating (thus retrodicting) past developments. If such an emulation- program manages to generate a *similar enough* dynamics, and if its behavior is interpreted successfully enough, it might serve for making some predictions of developments (in the subject system) in the near future. Such a program is called 'reactive animation' [7] [11].

[1] To avoid confusion with the traditional notion of an agent (on one extreme) and with a representation of an actual individual (on the other) I use the construct: 'culture-partner' (coined by Even-Zohar [10]). However, Louson and Atlan (2006) [23] have shown that an analogous strategy can be applied to intentional action by individuals, by connecting a schematic neural network to a decision making iterative mechanism. Both our efforts, although having much in common, (e.g. meaning is interpreted as a future strategy, discovered by the program in past iterations and stored in a memory device [3]) are just initial explorations. They cannot, at the current state, be amalgamated yet into a wider scope methodology for the study of CS, driven by human decisions.

However, attempting to reverse engineer a cultural system poses several interrelated problematiques that I will consider shortly (mainly from a phenomenological point of view, but also from a theoretical one). I would like to suggest that an evolution might have encountered in the past similar enough problems (in the same or in another system). Therefore, I further suggest that although evolution's time-scale is small (compared to the allotted time of a research project - its processes usually take up a much bigger 'chunk' of real time); and that while evolution can only yield satisfycing solutions (that are never complete, i.e. can never withstand a maximization test that an Economics 'solution' does), it might have managed to come up with ad-hoc, sometimes awkward strategies/solutions [28], which are at least *better then none*.[2]

Cultural evolution has been 'engineering' solutions for at least the last hundred thousands years (and biological evolution for hundreds of millions). Therefore, rather then trying to outdo evolution, I suggest that it might be wise to learn from it - adopt it's supra strategies - whenever possible.

To do that, it is necessary to study cultural systems within the context of high information-viscosity complex systems, i.e. study their dynamics not only in the bottom-up direction, i.e. utilizing a lower viscosity system as a reduction for a higher viscosity one, as our scientific organizational-culture dictates, but also in the top-down direction [7]. In other words, there is no choice but to get interested not just in what makes a system prolific and robust, but also in what makes it *creative and sophisticated* - in the propensity to make new information emerge, i.e. to come up with supra strategies.

To bring sophistication into the 'picture', I expand the use of the term 'viscosity', originally used by Lehn to account for a macro chemical system's predisposition to organize into interim sub-systems of supra-molecules [22], to include a system's propensity to come up with supra-strategies in general, thus creating another 'layer' of orders/patterns - increasing its sophistication - its depth of complexity.

This divergence in creativity, which does not correspond to a mere length of history, measured by the number of past bifurcations, is well known intuitively. Ancient cultures are *not* likely to produce more new cultural strategies than new ones [6] [9]; e.g. the Egyptian (15,000 years old) is not as 'productive' as the Levantine (250 years at most) residing in the same place and in the minds of most of Egypt's population; Bacteria colonies produce new spatial configurations or adopt sophisticated strategies containing more 'layers' of organization, when their environment (macro system) changes to nourishment-shortage [5] [1]; bacteria that have not changed for millennia, have new strands appear, when bacteria destroying agents are introduced to the macro system, and so forth.

Information viscosity is a parameter characterizing the length of the 'active tail' of an evolutionary path (of a current context enfolded in a culture) which is constituted of past quasi stable states/structures.

The longer this part of the tail, the greater the probability of emergent information units appearing, because there is a larger number of possible pairings between states (manifested as patterns/structures) of a given pair of evolutionary paths.

Each bifurcation by a sub system increases a system's amount of both structural and dynamic complexity by introducing an emergent pattern; and each vanishing decreases the structural complexity by making patterns (information gained in past bifurcations) latent. The 'creativity' of the system cannot be described, therefore, as corresponding to the entire length (number of bifurcations) of a coupling of evolutionary paths; but only as corresponding to the 'living' part of them, each kept alive by its own system's memory mechanisms.

The manifestation of the above as an apparently paradoxical behavior of cultural systems is also common knowledge. The 'old stuff' is usually kept prevalent in the outskirts, while these parts - the outskirts - happen to be also, in many or maybe even most cases, the most 'creative' – where new cultural strategies tend to appear [10].

Information viscosity cannot be used in isolation, since at each move of each system there is a change in a *different* amount of information (structural, dynamical or both).

However since both a model and a real world Inner World type sub-system (elaborated further in this paper) are related to the same macro system, the relation between information viscosity of one to the other can be used to gauge the required amount of sophistication/depth when a retrodicting effort

[2] A complex system is non-linear, therefore, a solution generated by replacing it with a linear model cannot possibly do, since it assumes in advance that once, in the course of acting out its dynamics, such a model reaches a stable state (around the values of the 'solution') it stays there constantly; in contradiction to our intuition that a cultural and/or biological system and our knowledge that any complex system maintains an apparently stable structure only for a limited period [8], and then either alters its structure or vanishes.

resulting in a reactive animation program, is carried out. Therefore, information viscosity can also serve as a property for grouping together different systems not by their material content (Biological, Cultural etc.) but by the amount of depth of their models.

Attempts to interpret properties of complex systems and their dynamics (called evolution) as changes in the amount of information contained in a system arose, because information-dynamics terms and thought-framework are suitable for handling such high-end systems[3]; at least, more suitable than the accepted complex systems methodology, which was developed with analogies of gas molecules in mind; the latter, 'behaving' according to a single uniform script/strategy [27]. In a culture, each element (context) is also a complex system; therefore at certain time-points the constituent system too has to alter its strategy/structure or vanish [20] (and when vanishing generates a change in the structure of its enfolding system thus enabling the enfolding system to continue its autonomous existence). Therefore, any and all moves of a complex system's dynamics in the high end viscosity domain manifest both disappearance and emergence of sub systems. Whether it is depicted as one or the other depends on the chosen resolution of the specific observation.

I therefore suggest the following top-down approach/supra-strategy:
Rather than ignore already existing definitions of amount of information (and jump directly to their probability 'roots', as the standard complexity approach has been doing) - that of Kolmogorov for structural complexity originated information, and that of Shannon for dynamically originated information, one can integrate both into our already existing complexity know-how.
This integration can be done by interpreting complex system dynamics (as developed by Anderson and others for Condensed Matter Physics [2] [13] [16]) as increases and decreases in the amount of dynamically originated information, contained and stored in a given system, while providing a partial scheme for handling the increase in structural information that unavoidably accompanies it [14].
I will prove, further in this paper, that a semantics mechanism of a cultural system has to be local, therefore each 'information area' develops its 'own language' and the enfolding system in which information quanta flow between those two information areas does the same, thus emanating a third language. Therefore, an increase in the dynamic complexity of a system necessarily entails some increase in its structural complexity.

2. Phenomenology of Cultural Evolution as a Motivation for a Modeling Strategy

To begin the 'journey' in a top-down direction, consider some prominent properties of cultural systems known intuitively to everyone, since she/he makes constant use of these intuitions to function as a culture partner.
From a phenomenological point of view, there are three immediately apparent sets (or, using a spatial metaphor, 'neighborhoods') of problems that these systems pose for the model maker:
1. In cultural systems not only single items – structures – (e.g. artifacts) proliferate and get distributed via a network, but also strategies and supra-strategies [21].
In fact *both* the following types of proliferation strategies are ubiquitous:
1.1 *Embedding* - new artifacts get embedded in existing strategies (that might have lost their former attached artifact earlier) and new strategies get attached to existing structures, and also;
1.2 *Emergence* - a new artifact may be distributed (i.e. it proliferates) embedded in a new strategy (e.g. for its use) and many times also attached to a supra-strategy (e.g. generating a need for it).
This hurdle can be theoretically reduced to the property: lack of an obvious upper limit of scales/resolutions. While a living cell (which is a high end information viscosity system too) has an 'obvious' spatial (its membrane) and temporal (its division into two cells) boundaries that can serve as a starting point parsing of an analysis – an attempt at reverse engineering a certain 'move' of its dynamics – [1] a cultural dynamics usually moves in several resolutions together (in real time and space); often, more than one of them is easily discernable and/or observable, with apparently no 'obvious' candidate for such a starting point parsing. e.g. each season the Milan fashion designers dictate not only which colors are this year 'in fashion' but also strategies, e.g. this year the skirts' length / neckline / waistline go up or down; as well as participate in a spatio-cultural supra-strategy which determines that Milan dictates Tel-Aviv's fashion and not vice-versa.

[3] These systems are not just cultural but also biological, e.g. the immune system, the RNA transcription system in a cell and so forth.

An immediate result in practical terms is that a data acquisition device may be, therefore, suitable for any but only one of a set of adjacent resolutions, while a model might require input from an upper or lower resolution of the same subject system (e.g. when the subject system utilizes an embedding supra-strategy for proliferation).

2. There are several properties of culture dynamics – possible moves of a cultural complex system from one quasi-stable state to the next by a decision making mechanism – other than a deduction by a logic-function, even a 'soft' logic one. These are known intuitively, and are generally recognized by their linguistics names: Polysemy, Metonymy, Redundancy, Empty Pragmatic Connectors and so forth. Since any one of them (or any permutation of their combination) might be a component of a decision-engine, driving a model forward by emulating a human decision, they all have to be incorporated into a simulation of any system enfolded in a culture, such as a city, but are not (or at least not yet) part of our Complexity based know-how.
Theoretically speaking, the second phenomenological handicap can be summed and reduced to one headline, that of *coherence*.
A model is an outcome of a reduction *from one complex system to another*. It is simpler, more transparent, with easier to control inputs and easier to measure outputs, and with a real time schedule suitable to a research project. The actual computer program that a model generates is run on a real-world computer; therefore, at any amount of structural-complexity contained by the model system, i.e. even when a research project manages to handle an enormously high structural complexity model-system, it has to be *coherent*; otherwise, a computer 'crashes'.
Contrarily, a human culture partner (and any and all collectives of humans, called operatives[4]) is patently *incoherent*. This phenomenon can be summed by the buzzword: a culture partner can make a decision and its contradiction without diminishing the integrity of its culture and without reducing its belonging to it.

3. A cultural system (as well as many Biological ones in the high information viscosity domain) demarcates its ad-hoc boundaries on its own, both in information space (chooses which contexts are relevant for a given decision and which are not) and in time (by manipulating its memory and its oblivion mechanisms). Therefore, its evolution (the fact that at a certain scale it went through a particular evolutionary-path – its structure has undergone a continuum of alterations *just so and not otherwise* - to be precise) determines also which of the data are *required* (because they are considered relevant) for a certain model *as well as* which data are *obtainable* (because they did or did not leave 'traces'). e.g. at any given time any city (as well as any part of it, such as 'the center') has several spatial boundaries depending among others on the point of view (thus, a city-part manifests a kind of Polysemy without the use of natural language; this Polysemy is manifested in a latent spatio-cultural 'language' of its inhabitants [24]).

In spite of the above, the modeling strategy that I propose does not offer a routine or a protocol for incorporating any one of the above decisions-engines (which are not a manifestation of a logic-engine); and does not offer a sweeping comprehensive solution for the coherence problematique. Neither does it offer a single general rule for decomposing the multi-scale manifestation of cultural systems resulting in a distinct all encompassing method for data acquisition.
It employs some of the standard components of complex system analysis to propose a general scheme, by which a particular simulation of a certain part of a case-specific system (in my case certain components of the Israeli City and in particular Tel-Aviv) apparently 'learns' gradually how to incorporate a '*reflection*' of these properties in the particular local rules, relevant to a particular dynamics of the system that it is required by the analysis maker to emulate.

In this paper I would like to concentrate *not* on the '*how*', i.e. not on the specific solutions that I happened to figure out for modelling the evolution of the Israeli city, but on the '*why*'.
My main proposition here is that such solutions (mine or any other that might be found in the future for any other sub-group of contexts enfolded in a certain culture) have to be *local*, i.e. discovered for each type of system and indeed sometimes even for a particular project of simulation, and *cannot possibly be comprehensive*.
This is a replica of a supra-strategy developed by evolution (both cultural and biological) in many cases. Namely, a real-world high-end information viscosity system copes with the excess in the amount

[4] An operative differs from the traditional 'agent' because of its capability of changing the rules that drive the logic engine it makes use of to generate its decisions [10].

of information flowing in it, by a sub-system (called an 'Inner World') that assumes the role of decision-making for the *entire* (enfolding) system, concerning a certain self defined and delineated area of information – a set of connected contexts that can be considered a lower resolution (higher scale) context, since it has a structure too. A model is therefore an emulation of such an Inner-World; it emulates decisions only for a certain sub-group of contexts and, like its real-world counterpart, deems the rest of the information flowing in the system irrelevant – it apparently converts information into information-entropy, in Shannon's terms [27]. Furthermore, and as another instant of reproducing a strategy, developed in the course of cultural evolution, I suggest that while 'learning', i.e. while accumulating its local stack of rules - a model must enjoy the privilege of making 'mistakes'. The capability to make what turns out to be in retrospect a 'wrong' decision and then apparently 'correct' it, a change (in the ad-hoc structure of its set of local rules) driven by additional input from the real-world system, depicted at a later iteration, has to be designed and incorporated into such a simulation program from the outset (in my case it is actually manifested mainly by the model's stack of defaults). Discussions of this, copied from cultural-evolution, supra-strategy and also of the strategy driving the choice to develop it separately for each system are deferred to another occasion.

However, the structure of the model that was specifically developed for spatio-cultural evolution and tuned to fit the evolution of certain parts of Tel Aviv is not in the focus of interest here and serves just as a source for examples. I also postpone to another occasion the substantiation of this modeling strategy as suitable for spatio-cultural evolution, namely for city dynamics, for which it is designed.
I rather suggest in this paper that *any* such solution (for modeling any context – any aspect of any culture) has to be a *local solution* (it is unavoidably tailor made), and attempt to substantiate it by a theoretical discussion, which uses spatio-cultural evolution as a source of examples, but *does not hinge on it*.

3. Cultural Dynamics, Rephrased in Information Terms: Redundancy and an 'Inner World' as Manifestations of Harmonization and Competition.

In this section I discuss, from a theoretical perspective, why a semantics mechanism – that attaches a future strategy to a current structure - in a high end system, is necessarily local. This discussion is based on the standard complex system dynamics i.e. the maximal reduction of any dynamics of a single complex system is into two tendencies: Competition and Harmonization [8] [16], as understood within a framework of information dynamics.
Cultural Complex Systems are typically in the high end domain of complex systems, i.e. they function where information viscosity is at its highest. They indeed share a time-period and a location (space) with systems, which function at a lower information viscosity domain, and these enable the higher domain system's existence by a perpetually streaming input and output; nevertheless, these systems cannot be used as a source of knowledge-infrastructure to calculate the dynamics of their high end counterparts, as a deduction from these inputs and outputs (as Anderson predicted in his famous "More is Different" paper [2]). Neither can these lower information- viscosity systems be a source for a satisficing replacement of strategies, developed in the course of the evolutions of their higher viscosity counterparts.
Cultural (as well as many Biological) systems are, depth-wise, far enough removed from the infrastructure of random networks[5], which in practical terms implies that they render useless much of the scale-free modeling approach's output, since those models require a connection to a randomized infrastructure[6]. Therefore, their dynamics have to be studied by executing a tracking process in a top-down direction too. This requirement is mitigated by the finding that although each system evolves

5 One cannot assume in advance that any and all of the constituents of their constituents, namely the systems which are elements of the enfolded system, behave according to a uniform dynamics/strategy, and thus there is no information contained in their projected – flattened - representation as a network, since it is randomized. This is a prerequisite of a scale-free model since otherwise the merged network is not scale-free; (this argument is elaborated further in this paper).

6 This requirement applies to all log/log type models, e.g. the universal scaling low of alometry of living creatures discovered by G. West and modified by D. Pumain to city dynamics [25]. The log/log modeling strategy has many advantages when compared to the more cumbersome supra-strategy, suggested in this paper. There are indeed systems-period pairs for which such models could be construed as satisficing; therefore, they did prove successful in many (but not all) of their respective uses, chosen intuitively to fit. However, analytic tools, required for examining (a priori or even a posteriori) whether a system/period pair is suitable for a log/log modeling have not been developed yet.

according to its unique evolutionary path, nevertheless, evolutions (both cultural and biological) tend to come up with similar solutions, similar supra-strategies, in different and some times far removed systems [3] e.g. the RNA transcription system within a single cell [1] and the entire immune system [7] as well as a city, which are far removed real-world scale-wise, have an inner world.

While such supra-strategies cannot possibly in any way be regarded 'universal laws' like the laws of Physics or Chemistry, and cannot be applied 'automatically' (because each system at each resolution has its particular evolutionary path) but have to be examined for aptness in each case, they might be applicable to a variety of systems and therefore 'borrowed' from one system to another [19]. In practical terms this tendency of different evolutions to generate similar supra-strategies, entails that such rules can be *transpositioned* from one project to another, e.g. when both concern the same culture (or cultures that maintain contacts) spatial wide scope contexts can be shared by a number of lower scope ones (in the same city residential and commercial areas may share a smaller scale evolutionary path of the entire city) thus shortening the 'learning' period of a simulation considerably.[7]

For the top-down direction, it is necessary to rephrase the know-how, developed for the dynamics of a complex system in information terms; namely, track the *changes in the amount of information* in the course of a jump of a system from one quasi-stable state to the next.
In this high information viscosity domain of complex systems (that can be Biological as well as Cultural), the two basic tendencies that exist perpetually in any and all complex systems: harmonization and competition – the emergence and coexistence of structures/species, and the elimination of structures/species in the course of a decided competition resulting in a bifurcation - are manifested as:
1. Proliferation creating redundancy; there are mechanisms that replicate *similar enough* information quanta [18], thus enabling an increase in the amount of dynamically generated information, since some of them are retained by memory mechanisms and others are replaced by a different quantum of information; a 'result' of a decided competition in the respective sub-system, in the wake of which a different dominant[8] structure/pattern prevails and at a later quasi-stable state proliferates too, and;
2. An 'inner world'; a sub-system that makes decisions *for* the entire enfolding system concerning a *self delineated* domain of information types, using partial (in both meanings of the word: skewed as well as missing parts) information, gleaned, filtered and modified from the flux of information flowing in the entire enfolding system.

Cultural and indeed all high-end systems do not just 'convert' already existing noise (information-entropy in Shannon's terminology) into information quanta, thus increasing repeatedly their dynamic complexity at each bifurcation from one quasi-stable state to another; namely, if there is a mapping between a structure (of the network representation) and a single strategy (continuum of events one scale lower), they maintain a constant strategy at all scales, the way a scale-free model does.
Contrarily to scale free log/log models, in addition to increasing the amount of dynamic information, high end systems, by emanating and 'operating' Inner World sub-systems, at the same time also convert *already existing information* apparently 'back' into noise – into information entropy, in Shannon's terminology[9]. Existing information, namely structures/strategies, accumulated in the course of their past bifurcations from one quasi stable state to another. This conversion of Shannon defined information into information-entropy has to occur because the Inner-World of the system has to *ignore*,

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[7] This maneuver was tried successfully in my study of the evolution of the Israeli city, including referring to human experts for input when necessary (which could be done also because of the mistake making capability built into the model).

[8] In a Markov type representation of the probabilities of the decision options prior to a state transition, the option with the highest attached relative weight/probability (the sum of all weights is one) is called dominant. Thus, when viewed as a single system, a bifurcation – a decided competition - apparently reduces both a system's structural and dynamic complexity; from at least 2 - the dominant structure and all the rest – to one. For instance, in a city when the low end resolution is far enough removed from the current one, e.g. when an agricultural area is turned into a 'built' area (residential and/or commercial) the actual street- pattern is a 'good' realization of the current dominant street patterns. It is similar enough to the pattern to be used in an analysis of the evolution of the street pattern.

[9] Therefore, while at any given single resolution of the information space, the amount of information + information entropy can be construed as a unit (a wholeness in D. Bohm's terminology) as Shannon found out, and thus could define the amount of change in dynamics originated information in a single move as a percentage of this unit, this wholeness (and as a result, this information amount measurement scheme) cannot possibly be expanded to a multiscale model.

for a given decision, some of the already accumulated information (regardless of the fact that it is still latently entrained).

For proof, consider for example a system that encounters as input from the real-world, a pattern, which is when compared to the one, its current rule generates, is *different than the dominant* one; thus encountering an information increase (Shannon defined) by the discrepancy between a depicted byte and the stored one that it is compared to; a byte, which is supplied by the rule, already in the stack contained by its Inner World.

To attach a proper (relevant) strategy (e.g. decide whether to change the outlay of an actual environment or leave it as is) the inner world must therefore 'move' up-scale to search for a context where there is no such discrepancy (if it finds one, it attaches to the pattern a different 'meaning' – switches on a different strategy, found in that different stack)[10]. At this stage even a small amount of similarity can suffice and the Inner World sub-system 'jumps to a conclusion'.

However, it can just as well not discern any resemblance whatsoever and it cannot go up-scale endlessly, since it is bound eventually to encounter a sub-system with a wide enough scope to include both options and thus cancel the discrepancy (and thus turning off that byte that has switched on and is keeping the on going search active).

Since a system is thus limited in the number of steps it can take up-scale, then (to avoid trespassing the brink of chaos (to that randomized network that contains both options) it has to do an apparent maximization of the scale, just short of the randomized one, and thus make a decision – choose the relevant context (if it cannot jump to a conclusion it will form an interim layer where the new structure is dominant). Then, it has to maneuver back down-scale, into the resolution where the discrepancy occurred, for the choice of a specific strategy. When it stops its up-scale 'movement', and performs a maximization (decide the competition between the options of future dominant pattern at the low resolution) information which is actually the structures of the non-dominant patterns (the 'losers' of the competition) has to be ignored, i.e. apparently discarded.

Consider, for instance, actual artifacts, constructed in the past according to that – what is by now – a non dominant pattern; these are turned into appropriate candidates for inclusion and incorporation in an oblivion mechanism (by lack of maintenance, by active destruction etc.). When such oblivion mechanisms function for long enough, such patterns disappear altogether; they are indeed entrained *only latently* in the tail of the respective context's evolutionary path, because the context evolved just so - to include a certain structure at a past quasi stable state - and not otherwise, i.e. these past dominant structures keep contributing to the amount of the dynamic originated information, while the amount of structural information contained in the context/ system *decreases* (when they are forgotten - no trace is left of them). Thus a system 'stays alive' - keeps its autonomy and is capable of increasing its dynamical complexity - without the inevitable corresponding increase in its structural complexity 'pushing' it over the brink of chaos (thus causing it to vanish).

An adequate model of such a high end system has to be considered an imitation or a *replacement* of such an inner world sub-system. The real world *enfolding system itself* cannot cope, at a certain level of information-viscosity and upward, with the excess of information flowing in it (to continue its autonomous existence) therefore it has to 'discard' some of the amount of structural of information that was accumulated in it, as the growth in the amount of structural information accompanied the growth of its dynamically generated information, in the past. Otherwise, since increase in the dynamically generated information (appearance of additional patterns/structures) inevitably increases also the amount of structural-complexity, the system must increase its structural complexity endlessly, and thus at a certain future stage, sure to loose its ability to make decisions at all (thus unable to increase its dynamic complexity – its just-so-ness) [11]; because it has reached such a wide scope where both (or

[10] In Tel-Aviv, housing clusters constituting the then (1935-60) 'new' streets, were as a rule, constructed on formerly agricultural areas and sand-dunes; therefore, their actual lay-out is relatively uniform i.e. it generally bears a good resemblance to the street-pattern.

Using a variety of visual material (mainly historical aerial photography and an actual survey, dating changes) a program followed the changes that were made to streets, constructed before 1930 by comparing them to a Visual Formalism of themselves (in an earlier date) and to a VF of the newer ones. It discovered a consistent tendency towards a greater resemblance to the pattern of the new ones, thus designating it as dominant, and thus delineating both types of areas as having a common relevant evolutionary path (and forming such an ad-hoc rule, for the corresponding stacks of local rules).

[11] The occurrence of a decision reached because a maximization has been obtained, thus converting the complex sub-system into a Purpose Controlled System, is possible but rare. The common case is that the oscillation down

more then two) decision options are components of *the same* large scale *context*; and therefore where a choice of one or the other *does not increase* the amount of dynamic information.
Consider for example navigating in a city and having to decide whether to turn left or right. Turning right leads to neighborhood A and left to B. If an operative reaches the scale of the entire city in the course of a decision process, then it is indeed true that both neighborhoods are parts of the same city, but that does not help arriving at its destination (which is in one of them).
In short: an accumulated rule has to be *relevant* (not too distant, depth wise) and not necessarily true.
If the observation is done only in one resolution of a cultural (or any high-end) system, then the amount of information entropy + information can be indeed regarded as a unit (however these units are different in actual size at each state) and thus it cannot possibly discern that the two perpetual tendencies (which are its dynamics' maximal reduction: harmonization and competition) are actually a result of the system participating in two different 'stories' performing two separate 'roles': as an enfolding system and as an enfolded one; e.g. when a competition is decided and only one structure survives the bifurcation (when looking from the point of view of the subject system as an enfolding system) each of the enfolded systems that got themselves eliminated by the competition has participated (from the point of view of the enfolded systems itself) in a harmonization for too long, and then at the next step trespassed the brink of chaos and disintegrated.

Since a CS moves forward in the real world only in time (it rearranges the intra-relations between its constituents at each bifurcation, while its projected flat information-space is only imaginary - a metaphor, i.e. it actually moves according to a time-like rounded logic; then, for a single move (or a small number of moves) it is impossible to distinguish between going up or down scale, and therefore this dynamics can be observed also in the opposite direction. Here is an abridged account of this dynamics as viewed in the opposite direction depth wise:
The scale of the upper most resolution, reached by a system (one short of a randomized network) can change, while the relative 'size' (structural complexity) of enfolded system remains a unit, namely without any change occurring in the structure of a lower scale enfolded system. E.g. a change that has occurred in a different information-area of the enfolding system might compel it to increase or decrease its entire amount of dynamic complexity, (and as it does so, increase or decrease the amount of dynamic information, contained in each of its sub-systems); nevertheless, the structure and thus the structural complexity of an enfolded sub-system may remain unaltered.
The observation that a system has not changed does not preclude, therefore, a change in its semantics; therefore, the choice of semantics from the larger scale stack, from which it is drawn, is different at different time-points; namely, the choice which stack of rules is referred to in the search for a relevant rule is necessarily also an *ad-hoc decision*; thus a given semantics is local time-wise, and thus local also in a projected information-space, represented as a flat network.
For instance, in the Israeli culture from the mid seventies onwards, residential clusters (which had no streets) have emerged, thus increasing the amount of dynamic information contained in the already existing side-streets that are mainly or entirely residential (e.g. by designating them 'old' in an additional interim Mental Map that divides a city into two spatial categories, old and new); this extra meaning was added without bringing about any change in their structure (and thus in the streets' actual physical lay-out). A model therefore, has to be capable of imitating (actually retrodicting) such a change, driven by changes in its stack of rules (its local semantics) and not by information, received form its sensors, thus its semantics mechanism has to be local – cannot possibly be designed as constant (a stack which only accumulates rules and does not discard them).

4. Conclusion: Copying Evolution is not a Silver Bullet; it has its Limitations and Problematiques too

A bottom-up direction for a construction of a model of a Cultural Complex System, cannot possibly suffice; thus a model has to reconstruct an evolutionary path from both ends of the scope/range of resolutions: the particular of the given move, originally marked as the target - to be analyzed or guesstimated - and the widest possible scope of prejudices - local rules and rule stacks - of the culture (which is found relevant).
Since an emulation of an Inner World sub system (like that of its subject system) cannot possibly 'allow' a trespass over the brink of chaos (into the randomized/noise infrastructure) to occur, and stops

resolution – up scale - is blocked by reaching a scale in which more of then one of the given optional strategies is enfolded.

its maneuver in the down resolution direction (apparently searching up-scale for a suitable context) just short of it (my spatio-cultural model emulates it by adding another interim layer), it 'forces' a competition to be concluded even if there is only marginal similarity between the dominant stacked pattern and the depicted one. This is discernible (in retrospect) since the enfolding system exists in the present, and its structure is currently depicted by a suitable sensor. However, if a former structure is retained, at the present, by a memory mechanism in another information-environment, and if our model is able to locate it, the same sensor is also able to depict it (and the Mental Maps Visual Formalism is able to record it) and thus reconstruct some of the subject system's evolutionary path.

While we do not know how to generate such a device in the bottom-up direction, a top down observation renders a common supra-strategy, reiterated in a great many known high-end information viscosity complex systems.
There is a sub-system - an Inner World which assumes the functioning of making decisions for the entire enfolding system concerning a limited number of ad-hoc self delineated sub-group of the entire variety of quanta of information, flowing in the enfolding system.
An inner world has a simplification and compilation component that filters and modifies just enough of the information quanta (many times at a lower resolution then that of the required decision) thus apparently from the point of view of a single system converting the rest into apparent information-entropy, but actually reducing the amount of structural information, while the dynamically originated information is latently entrained in a system's evolutionary-path (when viewed from the enfolding system looking backward in time, namely, utilizing a multi-scale model).

However, while the actual sub-system can be regarded in retrospect as delineating its own boundaries (in information space) determining which virtual 'areas' of the information network 'space' are relevant to the momentarily required decision, an artificial model generated as a reverse engineering attempt at emulating such an Inner World, has to make its decisions concerning relevance, constrained by what the actual inner world has already done, i.e. 'attempt' (actually designed in advance to alter its choice of context in the course of further iterations following a tendency) to make choices as closely resembling the real world ones as possible [28]; it has to go the extra step down scale (compared to a real Inner World).
Therefore, the replacement system - the model - has to be equipped with a capability of reconstructing the local rules of a particular semantics by utilizing a local-rules guided search, enabling it to choose and to 'explore' information areas which are *not the ones* designated at the initiation of the simulation program as its subject system; in other words, by converting semantics to dynamics (taking place in a larger time-span) the model has to 'learn' the necessary semantics mechanism locally; by tracking a larger (than the subject of analysis) relevant spatio-cultural context back in time and thus reconstructing the subject system's evolutionary-path at the required resolutions.[12] The longer the reconstructed path, the greater the probability that the particular analysis has reverse-engineered a similar enough dynamics compared to the one of real-world system.
This extra step increases the dependence of the probability of accuracy of a reverse engineering effort on the specific conditions, currently prevalent in the subject system; e.g. consider the rule: the more lower scale patterns become captive within later appearing higher scale dominant patterns, the more accurate the reconstruction.
This rule depends entirely of the specific momentary length of the active tail of the relevant contexts' evolutionary paths, while one cannot possibly guesstimate it prior to starting an analysis. However, the intrinsic dependence on the arbitrarily chosen subject system is mitigated by the finding that evolutions 'tend' to come up with similar enough solutions, and therefore a project can choose a suitable subject system (where a reconstruction of the evolutionary path is easier to accomplish) and then attempt a transposition of the results.

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[12] In my spatio-cultural model it is done mainly spatially; the model also 'learns' gradually where to look for areas where former dominant patterns are retained by a memory mechanism.

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