The General Principle of Maximum Entropy Production

Order as an emergent shortcut for increasing Disorder

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Abstract

The difference between order and disorder is hard to tackle, because they are not formally well-defined. Where the emergence of stable life-forms and evolution ('order') seem to defy the second law of thermodynamics, the actual issue is the absence of a generalized principle which explains the existence of both order and disorder. By combining non-linear dynamics and Markov blankets with the Maximum Entropy Production Principle, we propose a General Principle of Maximum Entropy Production, to explain the emergence of order, which actually speeds up disorder.

Introduction

As a consequence of the second law of thermodynamics, as (closed) systems tend towards higher levels of entropy, they will also tend towards higher levels of entropy-production rates. In other words, as systems (accidentally) yield structures or processes that increase entropy-production rates, it will *cost* relatively higher levels of energy to undo these structures again.

This principle also holds when these rates are increased only locally or temporarily.

I. Fractal Markov blankets

One of the difficulties in establishing quantitative metrics for systemic processes or complex-dynamic systems, is the absence of any pre-defined discrete boundary. I.e., the choice of a boundary of a dynamic system is always arbitrary and artificial. In practice, these are subject to anthropomorphistic bias. A perfect, scale-agnostic metric would enable comparative analysis between any pair of states, or processes. It would enable metrics between micro-states and macro-states.

For entropy production calculations, this holds even more. The concept of Markov Blankets has been very helpful so far.

Markov Blankets are artificial, conceptual boundaries around a system, which can then be seen as interacting with an environment. They can be defined at any level: a mitochondrium, a single-cell organism, a multi-cell organism, an ecosystem, even an economy. In principle, the biggest markov blanket would be the universe.

For entropy production in particular, the propagation from micro-levels up to macro-levels is in itself scale-free, of course. Every single cell in our body produces entropy, and escalates it to organs, processes, up to the scale of an organism. And this organism then propagates entropy into its local ecosystem/economy. All the way up until it dissipates into the infinite chaos at the macrolevel.

Again, any choice for a boundary of a system would be arbitrary. It would be much more convenient to consider a single Markov blanket which is fractal in structure. At least for entropy production this would make much sense, and would actually yield a generic way for explaining any process, and also enable scale-free metrics, both quantitative and comparative.

II. Abundant chaos

Given enough time, chaos and diversity in microstates (e.g. molecular interactions) will eventually yield some composite structures that produce entropy at higher rates. If the robustness of these structures is sufficient in time and space, even higher-order structures that build on these structures, may occu. These can also be robust and highly productive, and this continues evolutionary. The robustness is a tricky aspect, because the environment can change as well (including the ecosystem a structure exists in). To be able to adapt quickly enough to a changing environment, a form of selective destruction (at many structural levels) can yield the optimal amount of regenerative alignment (from micro- to macro-levels) with the new environmental parameters.

III. Saturation

This selective destruction will not only be accidentally encountered, but can more easily result from saturating processes (of entropy production). Given the complexity of the (organic) structures, there will be lots of processes that saturate (logistically). Examples are trees that loose their leaves in autumn, the death of an organism, or the apoptosis of cells in large organisms.
In the bigger picture, a structure with lots of saturating micro-processes can adapt more quickly to changing environments, and therefore produce more entropy (as a whole), then structures with less optimal regenerative aspects.
This holds for cells, but for organisms as well. A limited life-span enables the (local) ecosystem to produce more entropy, than a population of ever-growing organisms.
In non-linearity terms: the stable fixed point that holds the 'Markov blanket' together, becomes an unstable fixed-point. The multilevel internally directed entropy-production is saturated, and only an amount of externally directed entropy-production is left (dust to dust).

IV. An entropy-production attractor

From a non-linear dynamic perspective, the optimal alignments between entropy-production and saturation, at different micro and macro-levels, can be regarded as *attractors*. Existing structures prove to be both robust and adaptive, and are (some of the solution of) local and temporal optimae of composite entropy-production and saturation, in the current ecosystem or mechanical environment.
Changing environmental aspects will change the location of these attractors, and over time, new generations of organic structures keep following these attractors. Regenerative structures with the optimal speed of adaptation will continously align with the speed of the changing environment. This is what we call 'evolution'.

V. The generalization of order and disorder

The semantics have been solved this way. We consider living organisms (at all levels) as a form of order, but it is actually a facilitator for increasing disorder.

> What we call 'order' occurs locally and temporally, and serves as an *emergent accelerant*, a shortcut, for higher entropy production rates.

It allows for *cheaper dissipation*, and as such, statistically, robustness and composition of these structures will evolve over time. Order is an emergent aspect of increasing disorder.

VI. Conclusion

We have generalized the Principle of Maximum Entropy Production. It now explains the emergence of robust structures (organic life up to ecosystems and economies) as local and temporal non-linear alignments of composite levels of entropy-production and saturation, *that actually increase the systemic entropy production rate*.
As these structures are energetically cheaper than there non-existence, over time they evolve into more robust and composite, higher-order structures.
The trout not only defies the waterfall, but actually speeds up the water.