Visualizing the taxonomy of entropic and anti-entropic aspects

Visualization-series 01/2017

White-paper

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Events and trends in the real world are often collateral effects of trends in the undercurrents of the entropy of the given (socio-economic) domain. Next to a quantitative and qualitative analysis of these trends, their visualization may expose critical aspects for understanding these trends.
This requires a preliminary reference-set of canonical visualizations. The taxonomy of entropic and anti-entropic aspects is the ideal candidate for this set, augmented with some heavily simplified real-world examples from several social and economic domains.

Introduction

The study of non-linear systems is a rather new discipline. The rise of the computer-era actually kind of gave birth to this discipline, as significant research can only be done with lots of computing-power. Chaos-theory and the study of complex-dynamic systems, at first mathematical disciplines, are finding their way in adaptations to other scientific fields as well. We have witnessed so-called paradigm-shifts in Artificial Intelligence algorithmics, forecasting-models, and elementary particle physics. The study of ecosystems and meteorology are by itself studying non-linear systems. And the latest candidate is economics, with trends like evonomics and econophysics as typical non-linear and non-deterministic approaches to their domain. This, ofcourse, in contrast with the classical linear and deterministic modeling paradigms.
The common denominator in these paradigm-shifts is that a scientist does not primarily strive to understand the reality anymore (using deterministic and linear descriptive models based on a-priori assumptions), but rather tries to iteratively improve its model, using empirical models and feedback-loops (a-posteriori knowledge), without any real intellectual understanding of this model. The probabilistic bayesian inference is at the heart of this pragmatic but much more succesfull approach to descriptive modeling.

Entropy

As described above, the actual understanding of the underlying mechanisms in the scientific fields decrease. That is, in the sense that action and reaction can be deducted logically. One can understand waves and particles and their behavior from a linear and deterministic point of view. But the wave-particle-duality in physics only makes sense from a probabilistic point of view, and seem paradoxical from the classical deterministic point of view.
Weather-forecasts, voting-polls and deep-learning models typically express their predictions in terms of probabilities. The models are being finetuned in every stochastic iteration, based on empirical results (Bayesian inference). In this sense, some sciences become statistical and probabilistic subdisciplines of the motherly science of non-linear, complex-dynamic, chaotic systems: thermodynamics.
That is exactly the proposal of econophysics: to regard the economy as a thermodynamic, non-linear chaotic system, where every action will have some re-action, and where trends are continuously looking for (continuously changing) equilibria.
This does not mean that we cannot make any sense of this chaos, or recognize trends. On the contrary: it is the thesis of EntropoMetrics that the elementary logic of entropy can be used to expose trends in systems, by means of quantitative and qualitative analysis (metrics).

Visualization

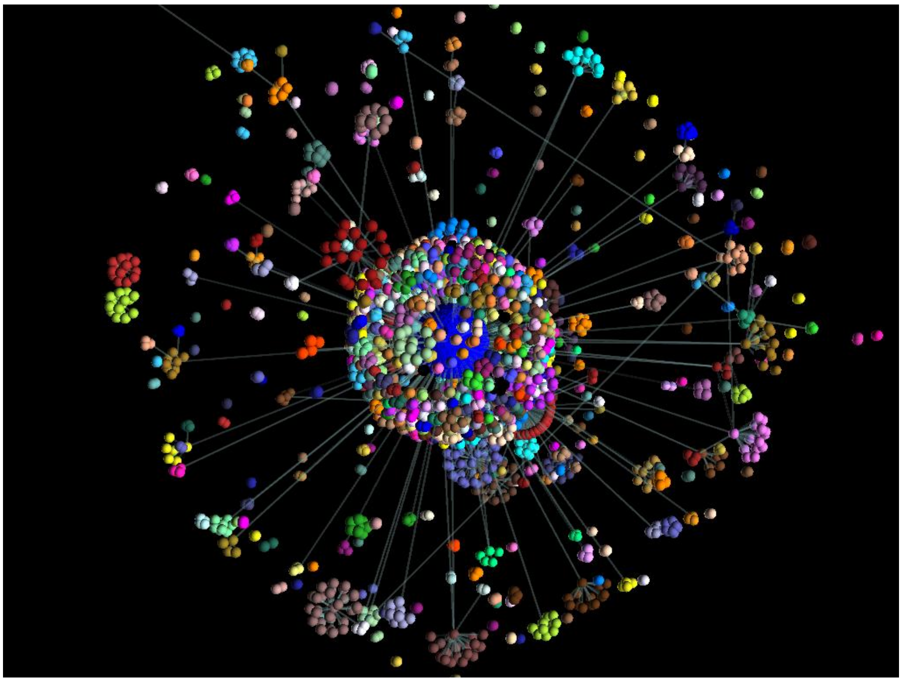
But just like a meteorologist looks at the dynamics in weathermaps, or a doctor to a patient to discover trends, this analysis and diagnostics of entropic trends can be assisted by visual representations.
And just like in meteorology and medicine, a vocabulary and a canonical set of typical entropic trends is needed to develop the gut-feeling and an intuition that meteorologists and medical doctors develop during their education. As part of a curriculum.
This will result in an entropological taxonomy: a systematic and hierarchical set of entropic and anti-entropic idiosyncrasies within complex-dynamic systems, described with terminologies such as patterns, trends, anomalies, equilibria, catastrophes, etc, and assisted by their visual, dynamic representations.
The development and construction of a taxonomy of entropological aspects is unprecendented, let alone the creation of set of corresponding visualizations. It is the first actual building block of the entropological paradigm as a scientific, empirical discipline.

Force-directed graphs

To be able to recognize idiosyncratic or anomalous trends in the entropy of complex-dynamic systems by means of visualization, the visual model should support some kind of native symmetry and a-symmetry.
This is typically achieved by spring-algorithms, that iteratively sort out a the cheapest topological layout.
Most notable is the Fruchterman-Reingold algorithm, which is specifically designed for this.
There is a large number of software-implementations of this algorithm. These implementations, however, show 2 major disadvantages for our use-case:

- they are only 2-dimensional
- the only support static input

The case for a 3D model as opposed to a 2D-model is obviously the much larger amount of potential symmetries in which local structures or the global structure can align into.
Also, some use-cases will need even higher dimensions to expose symmetries or a-symmetries, and the 3D-reduction is then our best visual option. Ofcourse, the quantitative tensor-metrics will expose them numerically, in any number of dimensions, but it will require the assistance of custom Deep Learning implementations.



The only software-implementation available that specifically supported both a 3D-Fruchterman-Reingold implementation and a dynamic model, was the Ubigraph library, but it was discontinued in 2015. Although we still have it on archive and are using it in our own modeling, it will probably have to be implemented again. The omnipotent VTK (Visualization toolkit) seems a good candidate, since it provides the 3D-FR algorithmes, but the interfacing and dynamic model must be implemented. The last resort is always a dedicated implementation, which could also use the latest GPU-technologies.

Relational and transactional dynamics

Depending on the actual usecase at hand, software-implementations for the logical modeling of complex systems vary from graph-based software (Neo4J, networkX, Gephi, etc), (which describe stateless relational topologies) to Markov-chain implementations (which describe stateful transactional topologies).
And given the multitude and diversity of entropological aspects and trends, it is likely that software-architectures for the aforementioned taxonomy are hard to generalize: the taxonomy itself is diverse, and comprises both relational and transactional topologies, and combinations.
Also, these aspects can be visualized in a multitude of ways, so it will be a severe challenge to maintain consistence within the reference-set, and its derivatives.

Illustrative, simplified real-world domain-simulations

Next to the illustration of the entropological taxonomy, the application to real-world scenarios is the actual goal.
The highest goal of our entropology is to show that a lot of the current trends in the global economy and the geopolitical playground and waves of privatization, for example, are actually *very similar in their anti-entropic profile*.

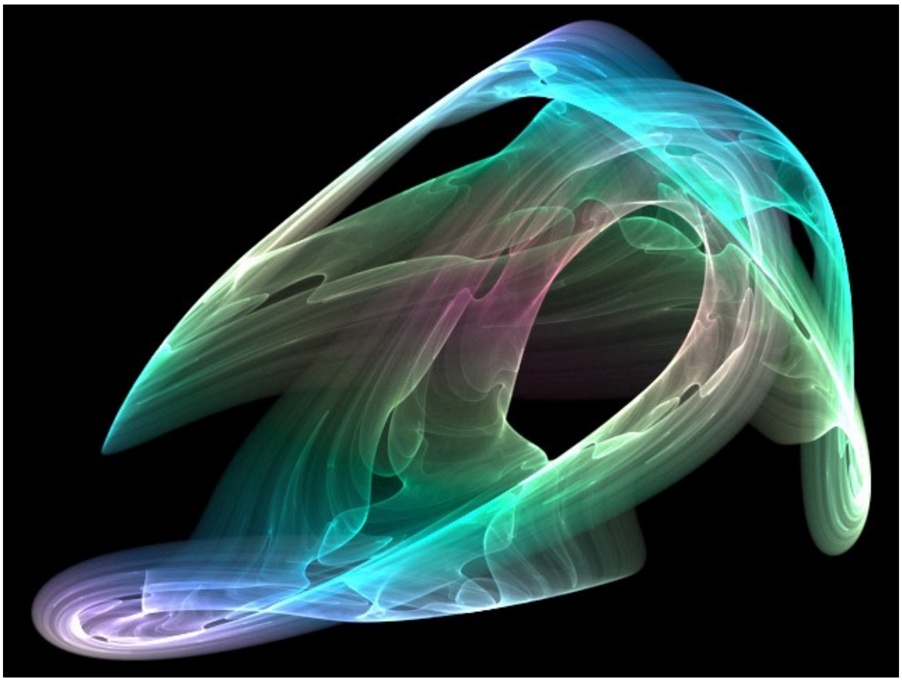


Figure 1: A 'strange attractor': chaotic, but with recognizable feats

Realtime visualization and compliance

After the consolidation of the entropological discipline as a diagnostic and qualitative authority, it is trivial that it will be used for new compliance models, and monitoring.
With the current state of technology, it is already possible to implement a real-time monitoring suite, that is subscribed to numerous event-streams and indicators.
With the use of visualization and DL-techniques, enforcement of the compliance is within reach, theoretically.
In practice, for such compliance to be implemented, it requires the formalization of the entropological alignment of self-interest and systemic interest; the incentive for big organizations to not kill their host.
Until then, entropology just helps to make some sense of what is happening in the world.

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