Title: "Edge of Chaos: The Elan Vital of Complex Phenomena"
Extended version of the ECCTD2020 Plenary Talk for the Chua Memristor Center (CMC)

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Abstract: Complex phenomena may emerge in an open system if and only if some of its components operate in the locally active domain. This concept, known as the Local Activity Principle [1], may be interpreted as a new Law of Thermodynamics, envisaging a non-monotonic trend for the entropy as a function of time in non-closed systems. The Local Activity Principle allows to explain the hidden mechanisms underlying emergent phenomena in the most disparate fields, from ecology, to biology, from physics and chemistry to electronics, allowing to predict the origin of complexity even in economics and in sociology. To cite but a couple of significant examples,
only by applying the concepts from the Theory of Local Activity [2] may one gain a deep insight into the emergence of heterogeneous patterns in homogeneous media, what Turing [3] called Instability of the Homogeneous, and Ilya Prigogine [4] defined as Symmetry-Breaking Instabilities, as well as resolve the widely-known paradox, which mesmerized Stephen Smale [5], when he observed that coupling dissipatively two identical cells, being silent on their own, allows to wake them up.
This three hour-long video lecture presents the foundations of the Theory of Local Activity, with special emphasis on the Edge of Chaos, a subset of the locally-active domain, in which the seed of complexity is truly planted. The theoretical concepts are explained with illustrative examples from electronics, and biology. A major part of the lecture is devoted to the exploration of the fascinating dynamics of the Hodgkin and Huxley model [6], universally recognized as the most accurate mathematical description of a biological neuron. The Theory of Local Activity allows to shed lights into the origin of the All-or-None spiking behaviour of our neurons, a mystery which remained unsolved for 60 years [7] since the 1952 seminal work of Hodgkin and Huxley. A historical journey through the path which led to the first observation of Action Potentials in the response of biological axon membranes, as well as through the missing opportunities in the discovery of the electrical circuit elements of major relevance in their internal structure, namely the memristors [8], which sodium and potassium ion channels essentially are [9], provides a gentle introduction to this lecture, which represents a legacy to the next generation of scientists interested in exploring complexity in our lives, which is an essential pre-requisite to address societal challenges, such as the development of rigorous diagnosis tools for ion channel pathologies.

References

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