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Book Review

Local Activity Principle, by Klaus Mainzer & Leon Chua. London: Imperial College Press, 2013, ISBN 978-1-908977-09-0. 443 pages.

A first warning; this is a very serious and advanced approach to nonlinear dynamics in the edges of chaos. The book is written in two different styles, each could have been singly presented as its own book, and both have extensive references to their own work. In order to understand (not necessarily to accept) all the arguments used by Mainzer, the references are in a series of his books, some only in German, and are philosophically cast when considering social and economic arguments. It is easier to read that part first if you have some familiarity with work on sociodynamics and risk in small groups which have been treated in past issues of *NDPLS*.

Those who want to read Chua's contribution which is based strongly on a very long series of graphic models in the *International Journal of Bifurcation and Chaos*, it is perhaps best to read his chapter 2 first, with coloured map pictures. Then come back to the algebra, only if you have got Wikipedia on PDE notation and Mathematica, ORBDE, or The Nonlinear Workbook by Steeb (2014), if you want to run any related software. You will need more than student texts on algebraic functional Analysis. Chua gives no list of working programs that could be bought and downloaded. I find that lack is damning for the beginner. Time-series packaged analyses using indices like Lyapunov exponents can be help in an exploratory manner.

The book has a convoluted style which makes it difficult to define clearly what the local activity principle is; it is a way of describing the emergence of complex biological patterns, where complex means non-homogeneous patterns. Chua has offered some various definitions. I quote one going back to 1999, "by invoking its 'negative' version and deriving a set of analytical inequalities for calculating the parameter range necessary for the emergence of a nonhomogeneous static or dynamics pattern in a homogeneous medium operating under the influx of energy and/or matter." Complex systems must be transformed into discrete special regions where the visualizations can be computed.

The definition of the process being modelled is given initially in reaction-diffusion equations, using classical partial differential calculus. Using an algorithm to find equilibrium points, the Jacobian matrix of the equations and the equilibrium points are determined, and we then classify each cell parameter point at the equilibrium point into one of three distinct categories, that are (a) locally active and stable – by definition at the edge of chaos, (b) locally active and unstable, or (c) locally passive. Type (b) is relatively very small in space.

The chapter works in detail through some examples, drawn from chemistry and biology; they include the theories of Brusselator, Gierer – Meinhardt, Fitz-Hugh Nagumo, Cardiac Purkinje Fiber, and Oreganator derived from the Belousov-Zhabotinsky reaction.

Many examples of Edge of Chaos and Bifurcation regions are shown in extensive multicoloured maps, in active and passive, unstable and stable cases. These can usefully be read intuitively without having to follow the details of the algebra generating the images. That indeed is the intention of Chua's approach here, which is spectacular.

Chapter 3 on the Expansion of the Universe can be treated as independent and ignored unless you are interested in string theory, quantum cosmology and symmetries.

Chapter 5, on the Local Activity Principle and the Evolution of Life expresses Mainzer's brief treatment of Brain Dynamics. This is where nonlinear cognitive psychology does get explicit mention, so I review only it. There is a brief discussion of top-down bottom-up representation yet missing the notion of feedback, which I would have thought would indeed link to Chua's neural network maps. Brain dynamics that are linked to consciousness is thus mentioned on page 193, but it has not followed the recent work reviewed by Dehaene (2014) or Tegmark (2014). It is a research area that is being published in profusion and evolving rapidly.

There is given (p. 344) in calculus a Master Equation of Sociodynamics by Weidlich. It is a dynamical balance equation, but not in a computer visualization. I would have found it helpful here if the network maps were worked through to compare with the simpler equations like those for the Brusselator. Mainzer makes no attempts to use models of mind and consciousness by extending his use of complex neural networks, though there is a mention of ECG and EEG. It is noted, unsurprisingly, that complicated maps of neural brain regions located by fMRI are much more intractable to plot. The examples used by Chua in chapter 2 do not have the structures like those described by Balduzzi and Tononi (2008), which have important properties with gaps in time, and information deletions, which can represent shifts and tensions between local and global interactions. Bayesian probability and Hopfield networks are needed to capture some properties of consciousness.

In the last chapter, 8, it is proposed that "the concept of local activity has deep roots in the cultural heritage of mankind." We travel from Aristotle to Leibniz, then via Newton to Bergson's *ėlan vital*, on to Nietsche and a "will to power", Talcott Parsons "theory of action," and Luhmann's Systems Theory of Society, ending up (temporarily, we assume) with Habermas' theory of communicative action. They conclude that "The local activity principle also tells us that acting at the end of chaos opens new changes of creativity and innovation."

One can be fascinated with the graphics and the fractal analyses of $1/f^b$ without making much of the social philosophy and an appeal to international democracy.

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