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Boolean Delay Equations: A Simple Way of Looking at Interactions and Extreme Events

Michael Ghil (1,2)
(1) Ecole Normale Supérieure, Paris, France, (2) University of California, Los Angeles, USA

Boolean Delay Equations (BDEs) are semi-discrete dynamical models with Boolean-valued variables that evolve in continuous time. Systems of BDEs can be classified into conservative or dissipative, in a manner that parallels the classification of ordinary or partial differential equations. Solutions to certain conservative BDEs exhibit growth of complexity in time; such BDEs can be seen therefore as metaphors for biological evolution or human history. Dissipative BDEs are structurally stable and exhibit multiple equilibria and limit cycles, as well as more complex, fractal solution sets, such as Devil's staircases and "fractal sunbursts."
BDE systems have been used as highly idealized models of climate change on several time scales, as well as in earthquake modeling and prediction, and in genetics. BDEs with an infinite number of variables on a regular spatial grid have been called "partial BDEs" and we discuss connections with other types of discrete dynamical systems, including cellular automata and Boolean networks.
We present recent BDE work on damage propagation in networks, with an emphasis on production-chain models. This formalism turns out to be well adapted to investigating propagation of an initial damage due to a climatic or other natural disaster. It thus serves to study economic impacts of extreme events, as well as extreme disruption of a network of interactions.