Observation of chaos in small networks of Boolean-like logic circuits

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'Boolean chaos' is observed in a simple network of electronic logic gates that are not regulated by a clocking signal [1]. We study a network three nodes realized with commercially available high-speed electronic logic gates. The temporal evolution of the voltage at any given point in the circuit has a nonrepeating pattern with clear binary state transitions and displays exponential sensitivity to initial conditions. The resulting power spectrum is ultrawide band, extending from dc to beyond 2 GHz. Because the circuit includes feedback loops with incommensurate time delays, it spontaneously produces dynamical states with the shortest possible pulse widths, a regime in which time-delay variations generate chaos. The observed behavior is reproduced qualitatively in an autonomous Boolean model with signal propagation times that depend on the histories of the gates and filtering of pulses of short duration [2]. Our device may be used as a building block in secure spread-spectrum communication systems, an inexpensive ultrawide-band sensor or beacon, and possibly for high-speed random number generation. It can also be used as a convenient platform for testing theories on complex networks. Efforts are underway to investigate chaos synchronization and private communication using these devices, including a parametric study on the sensitivity of the synchronization quality on network delays.

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