Recent work by Corron et al. [1] shows complexity in a piecewise linear system, where a nonlinear switch causes chaos in an otherwise linear LRC oscillator.

\[ u - 2R \ddot{u} + (\omega^2 + R^2)(u - s) = 0, \quad R = \log(2), \quad \omega = 2\pi, \]

Guard condition: \( \dot{u}(t^*) = 0 \rightarrow s(t^*) = \text{sign}(u(t^*)) \)

Sampling \( s(t) \), rather than \( u(t) \), reduces data storage for signals used in radar. The piecewise linear nature allows for a matched filter to recover \( s(t) \) from \( u(t) \) with noise.

**Goal:** Increase the speed of the system by substituting the LRC oscillator with a time-delay feedback loop.

**Experimental Setup**

- Logic gate
- LGA (log amplifier)
- Power splitter
- VGA (variable gain amplifier)
- Feedback loop
- \( \tau_f \approx \tau_c \approx 42 \text{ ns} \)
- LGA = log amplifier
- VGA = variable gain amplifier

**Experimental Results**

High speed chaos maintains piecewise linear nature.

**Simulation Results**

Piecewise linear model shows good agreement.

**Bandpass Characteristics of VGA**

Bandwidth and center frequency change for different \( v_{\text{ctl}} \):

- Discrete VGA:
  \[ v_{n+1} = g(x_n)v_{n-\tau}, \quad g(x_n) = \begin{cases} 1.14 & x_n \geq 0.93 \\ 0.53 & x_n < 0.93 \end{cases} \]
- Discrete LGA:
  \[ w_{n+1} = \beta \left( 1 - \log_{10}(\|v_{n-\tau} + \epsilon\|) \right), \quad x_{n+1} = \sum_{n-\tau}^n w_n/\tau, \]

**Delay-Differential Equation Model**

Time-delayed feedback loop:

\[ v(t) = -\Delta_{H/L} v(t) - \omega^2_{H/L} \int v'(t') \, dt' + g(s(t-\tau_c))\Delta_{H/L} v(t-\tau_f), \]

Logarithmic amplifier:

\[ a_2(t) = \omega_L(\beta \left( 1 - \log_{10}(\|v(t) + \epsilon\|) \right)) - a_2(t), \]

Digital logic gate:

\[ s(t) = T \left( 1 - \tanh(y(a_2(t) - T)) \right) \]

Model parameters are measured from experiment.

**Summary**

We demonstrate high-speed piecewise linear chaos using time-delayed feedback for fast oscillations and control. In the future, we will tune model parameters for better quantitative agreement.

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