Generalized Synchronization of Spatiotemporal Chaos

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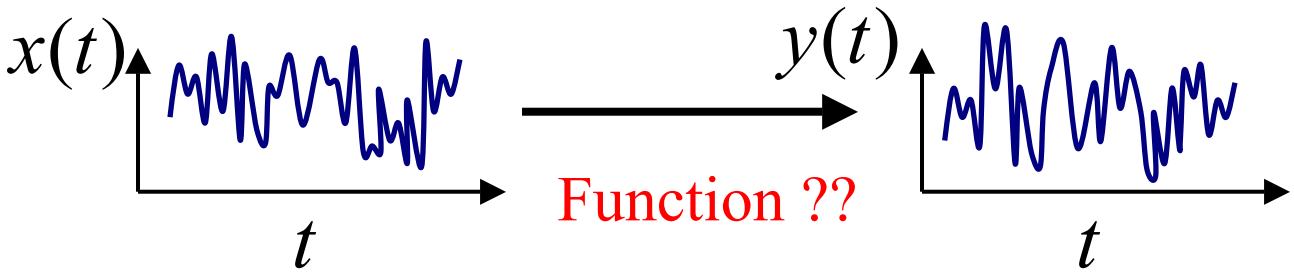
Overview

- Motivation: Generalized Synchronization
- Our Nonlinearity: Liquid Crystal Spatial Light Modulator
- Experimental Setup: Opto-electronic feedback loop
- Experimental Results
  - Observation of Generalized Synchronization
  - Parameter Dependence of Synchronization
- Summary

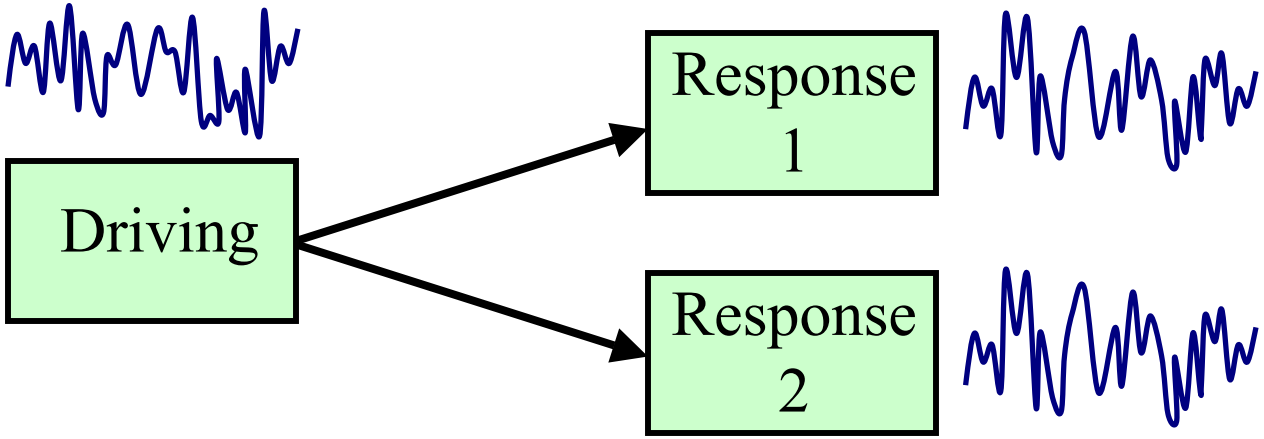
Generalized Synchronization (GS)

- What is it?
  - Functional relationship between drive and response:



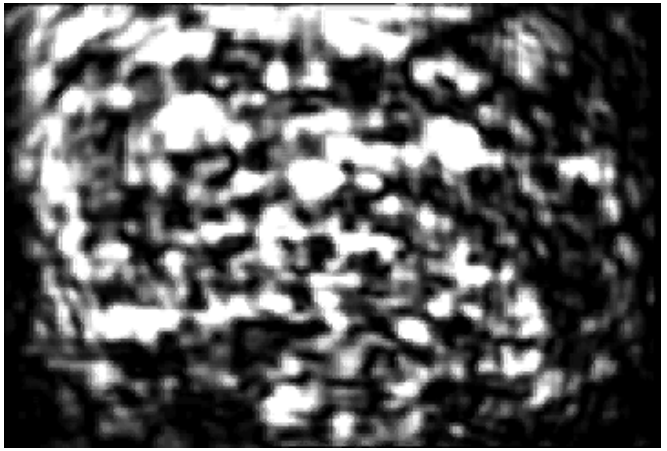
$$y(t) = F(x(t))$$

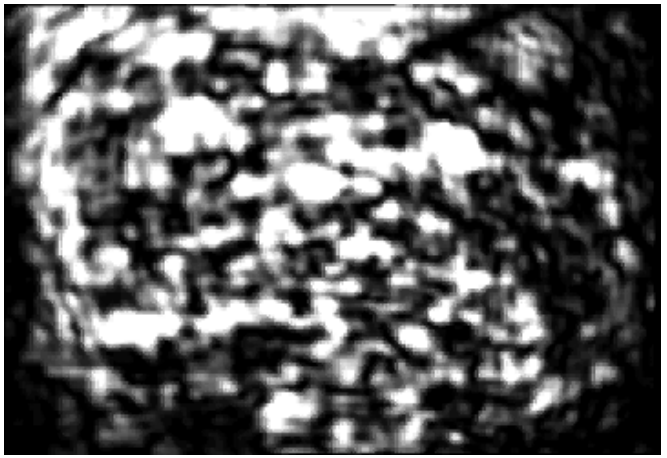
- How is it determined?
  - Auxiliary system approach:



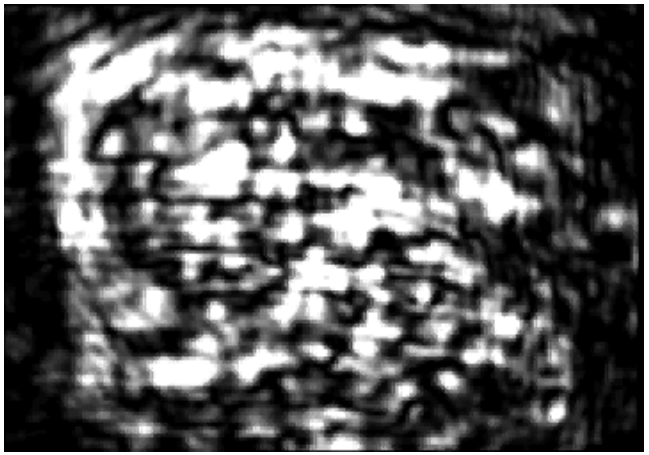
GS of Spatio-temporal Chaos

Response Patterns

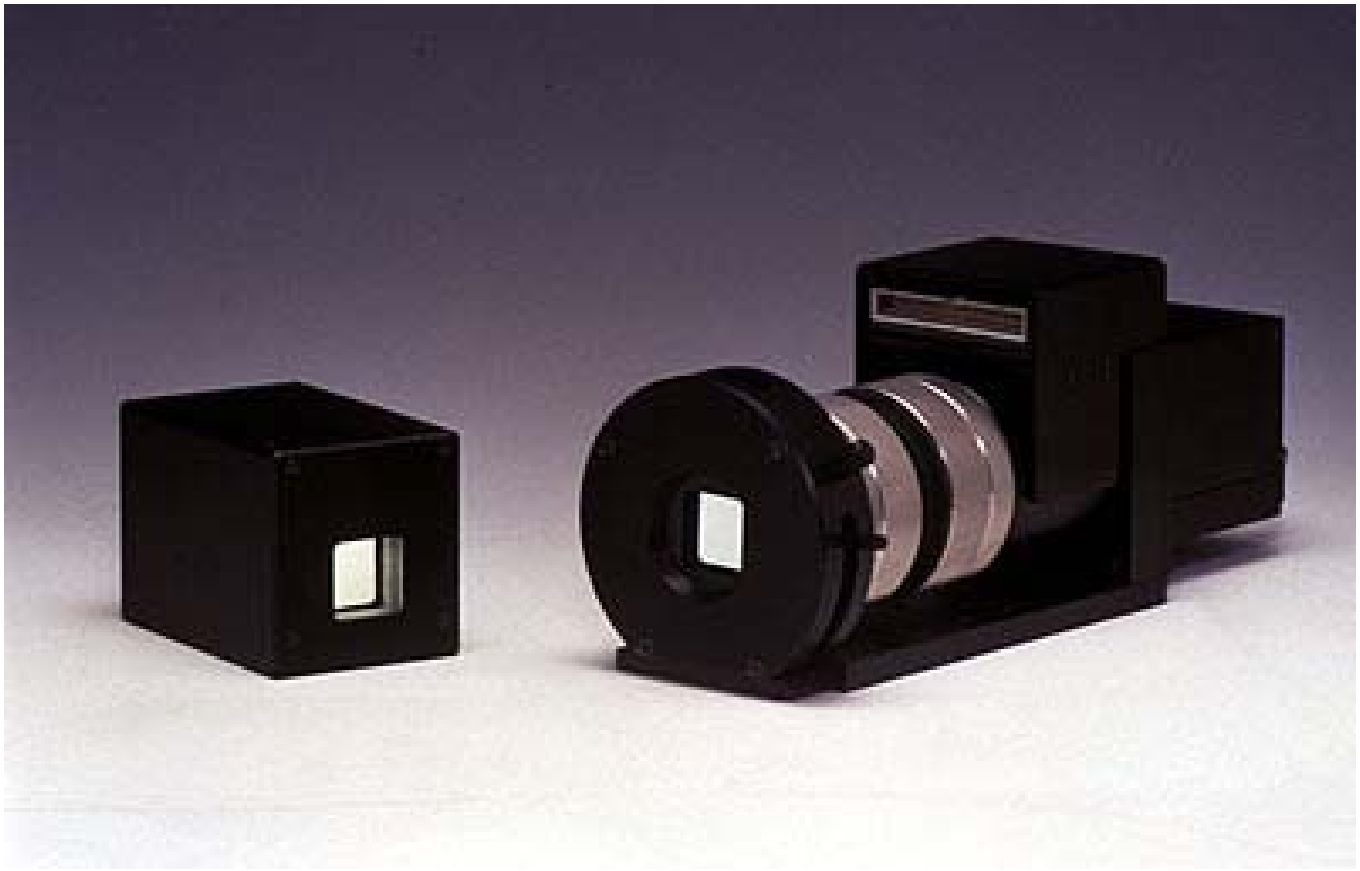




Drive Pattern



Liquid Crystal Spatial Light Modulator (SLM)



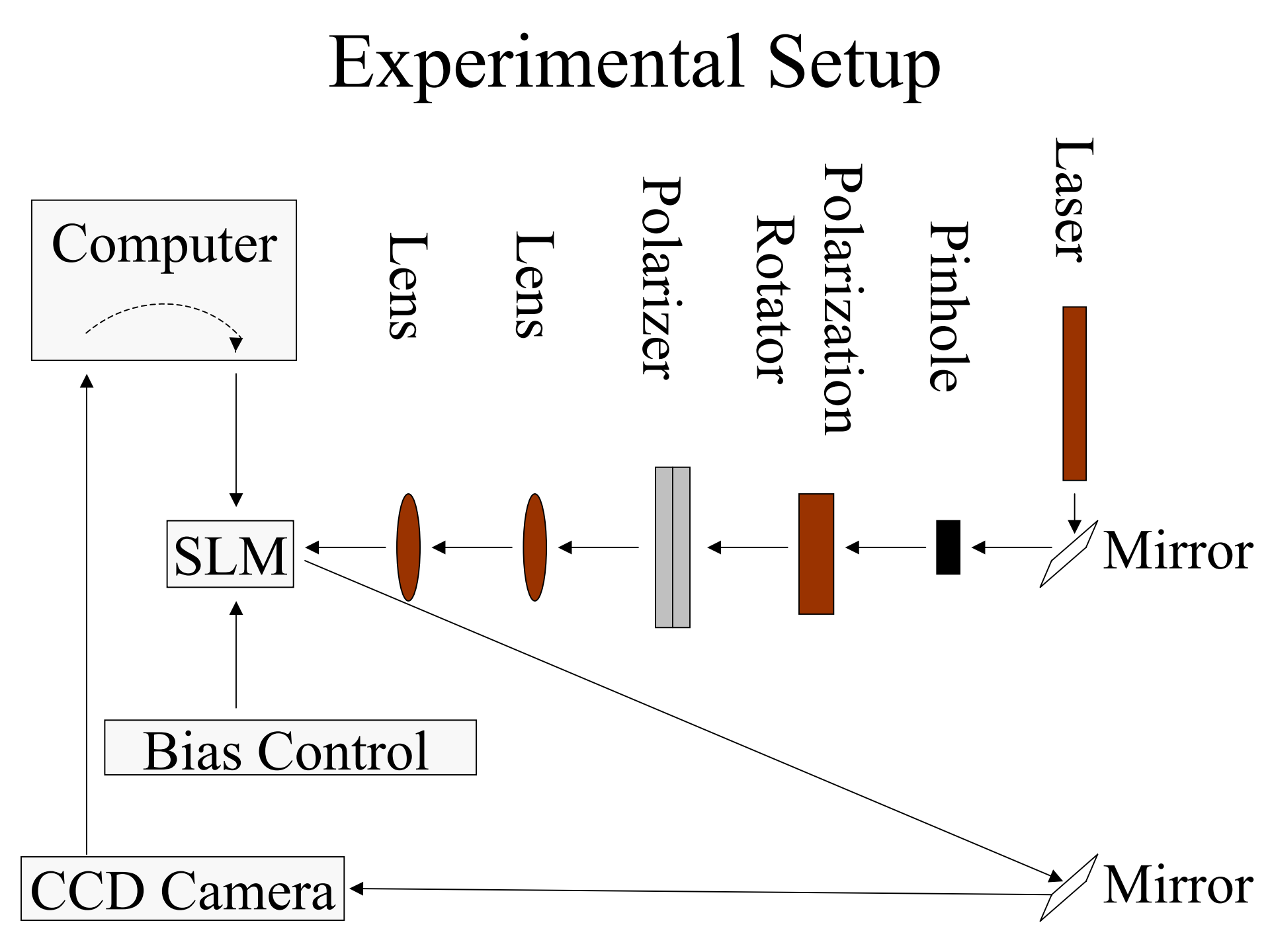
Liquid Crystal Spatial Light Modulator (SLM)

- Nonlinear Element in Experiment
- Computer-Controlled
  - takes VGA signal from computer, displays intensity image on an LCD within the SLM
- Intensity patterns modulated by liquid crystal inside SLM
- Bias Voltage-Controlled
  - varies amount and speed of deflection of liquid crystal molecules
    - speed at which liquid crystals molecules deflect is additionally controlled by speed of external (spatiotemporal) drive signal
  - controls feature size

Experimentation

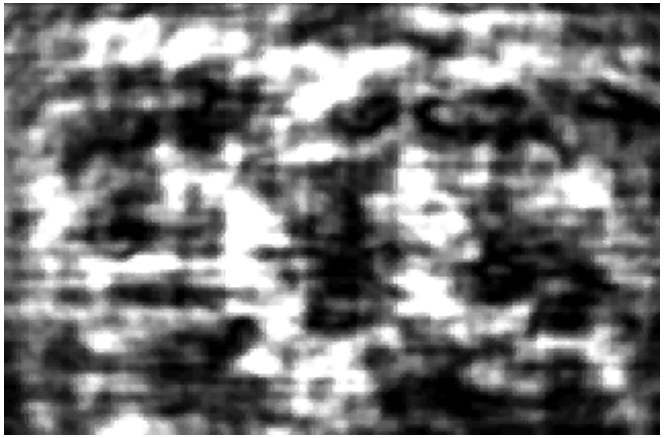
- Created drive and response movies using closed and open-loop configurations
  - bias voltage mismatch
- Gave each response movie different initial conditions
  - initial conditions determined by the last image left on SLM
  - each response began from different frame of drive movie

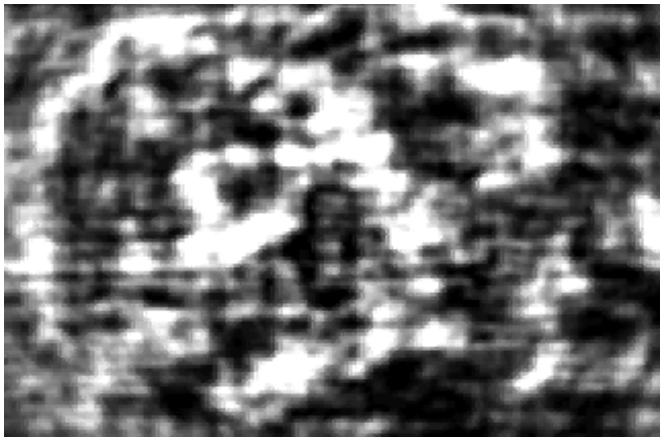
Experimental Setup



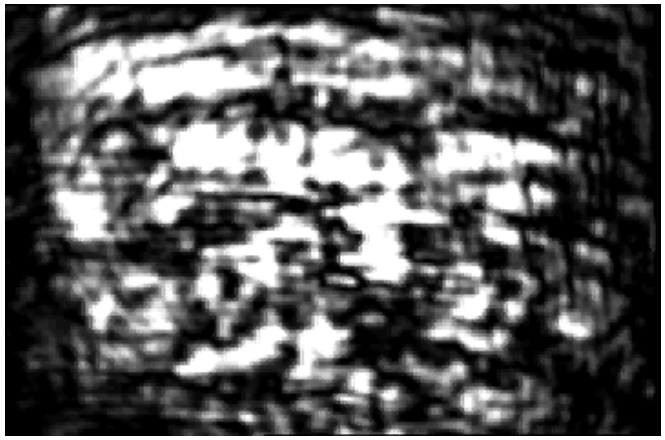
GS of Spatiotemporal Chaos

Response Patterns

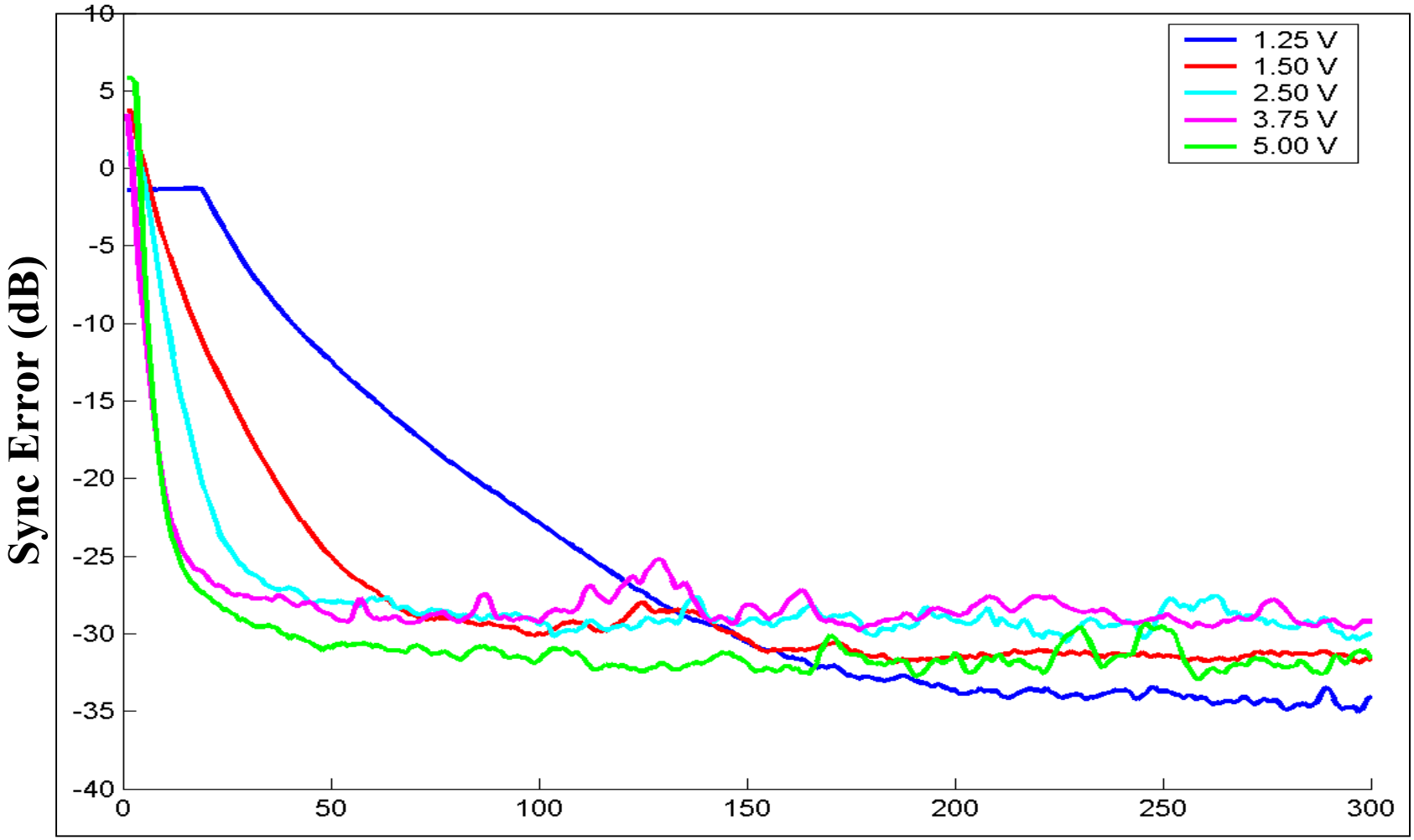




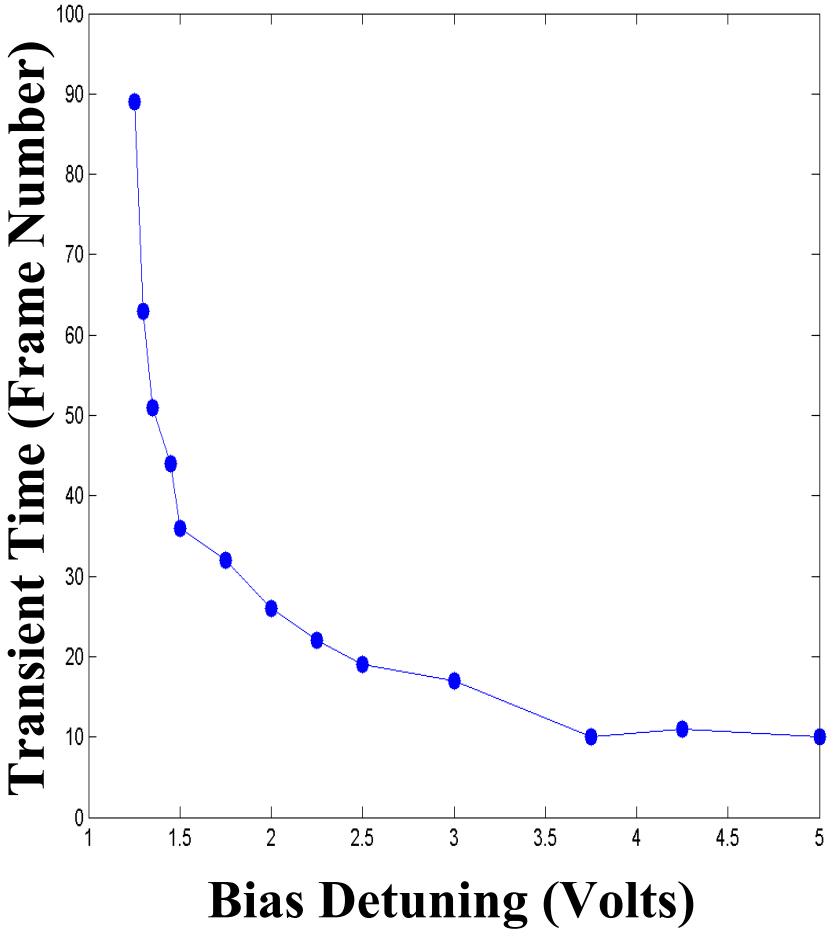
Drive Pattern

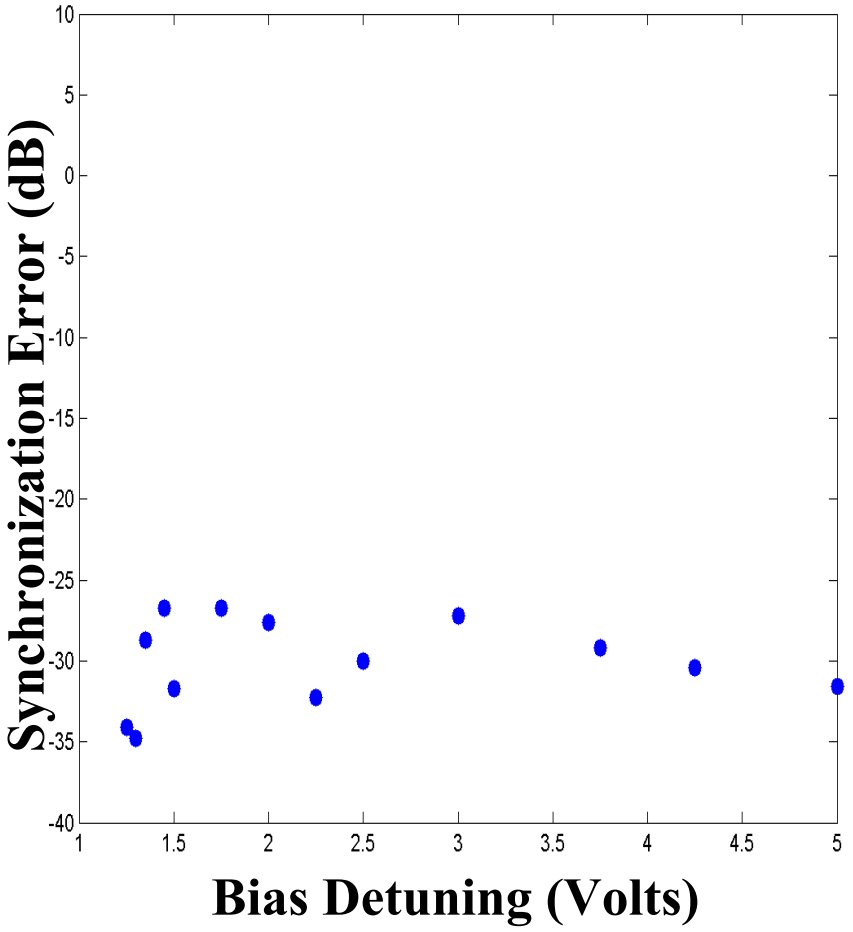


Synchronization Error vs. Time for Drive Signal at 1.50V

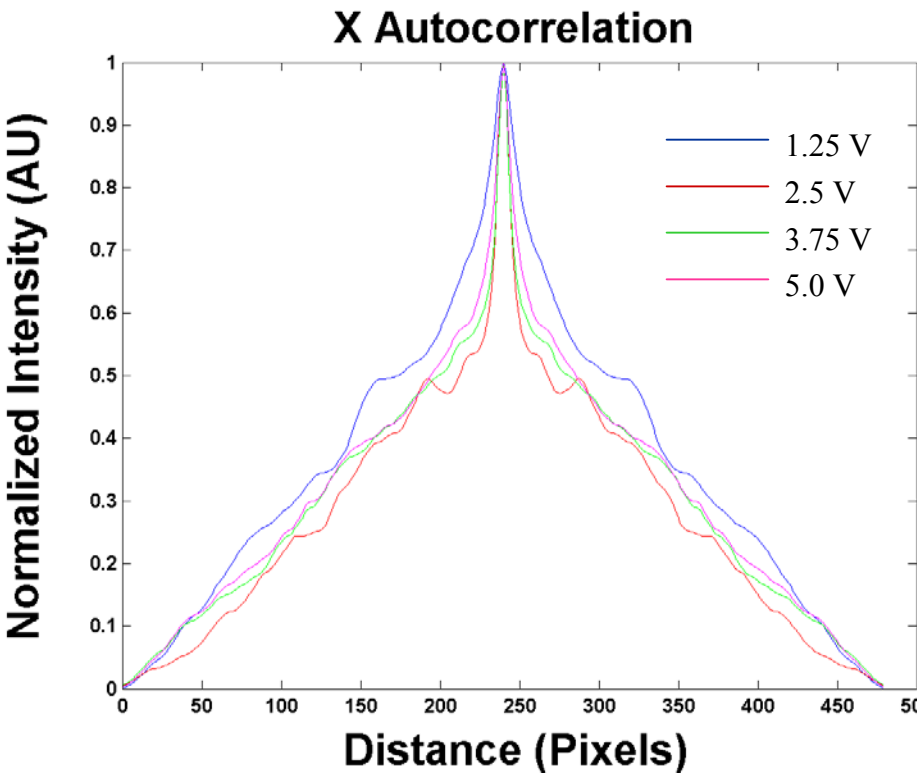


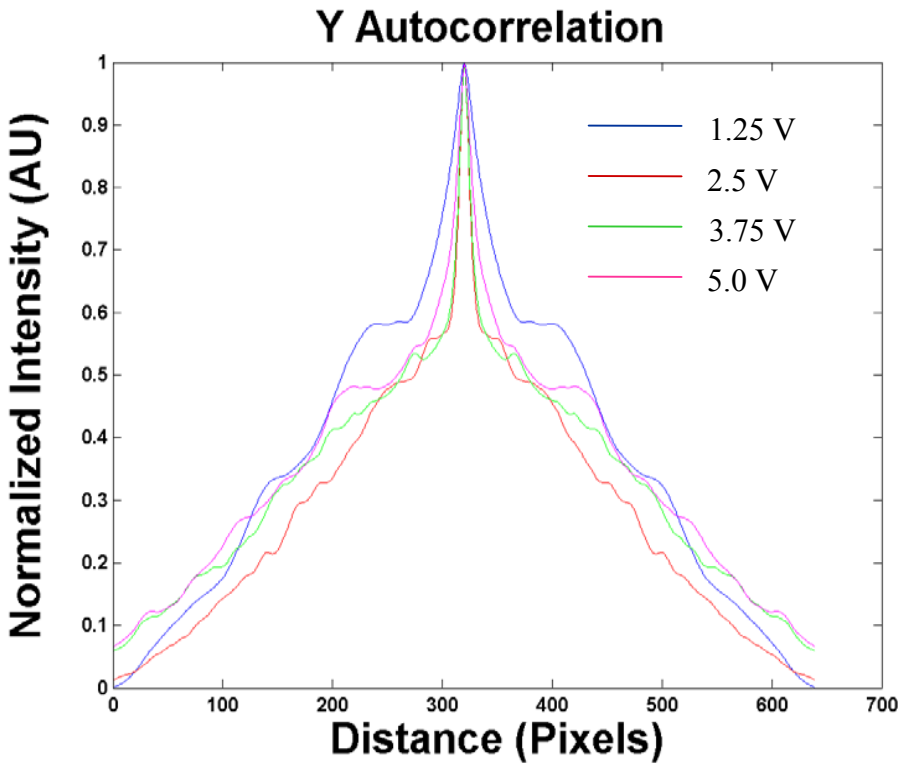
Bias Voltage Dependence of Sync. Time & Sync. Error





X, Y Autocorrelation of Grain Size for Responses at Different Bias Voltages





Summary

- We have demonstrated generalized synchronization of spatio-temporal chaos in an opto-electronic feedback loop using a liquid crystal Spatial Light Modulator
- Different initial conditions of responses caused transients to occur before synchronization
- Synchronization showed parameter dependence on bias voltage
  - synchronization time varied inversely with bias voltage
  - synchronization error did not vary much with bias voltage: once responses synchronized, they stayed synchronized
- Auto-correlation length plots show grain size dependence on bias voltage