Numerical Models of Semiconductor Lasers with Time Delayed Opto-Electronic Feedback

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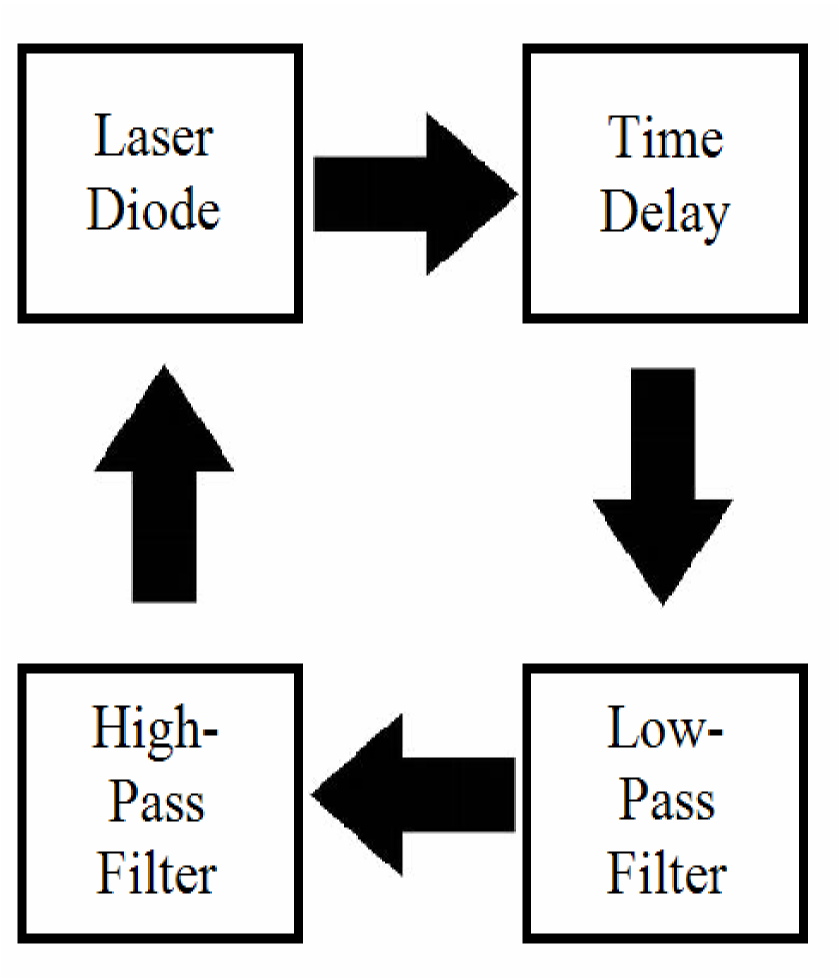
Introduction

- We intend to use this system as a building block to understand a network of lasers which can be used in sensor applications.
- Time delayed semiconductor lasers systems can also be used while studying patterns on firing neurons and the dynamics of epidemics.
- We compare simulation results to experimental data.

Model Setup

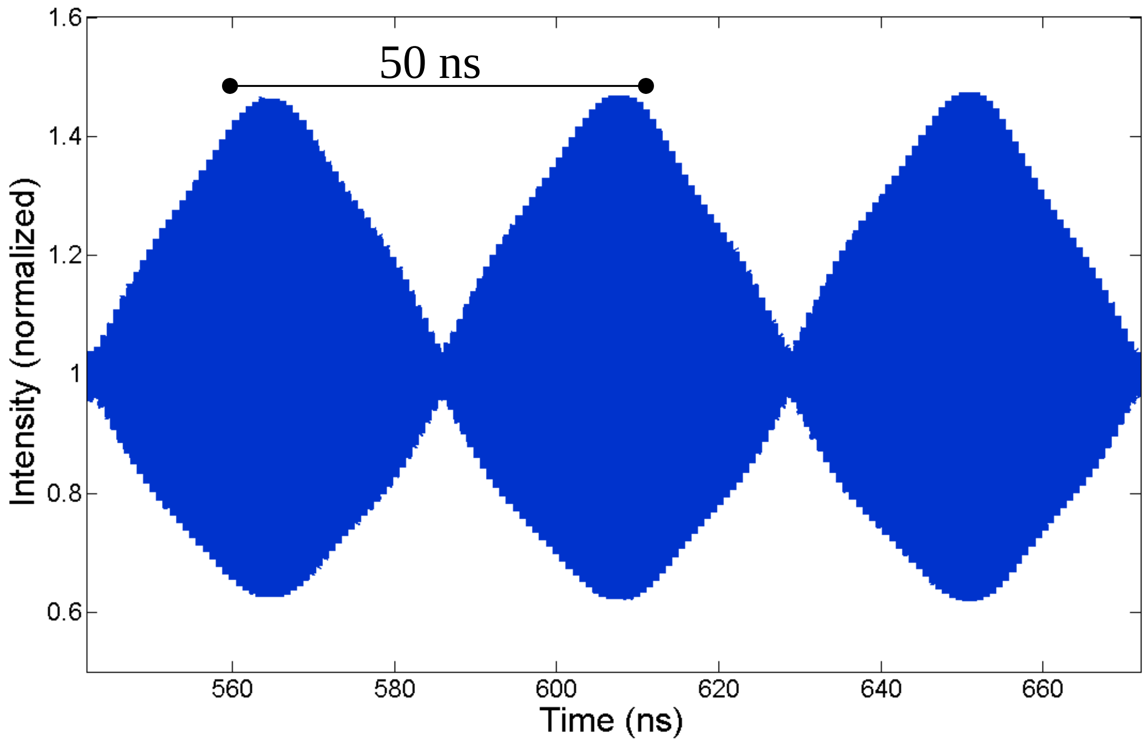


- Derived equations for photon number, proportional to intensity, and carrier number from the electric field equations for a semiconductor laser.
- Experimental optical and electric time delays are treated as a total time delay sum.
- Our model allows us to verify experiment and explore a greater range of parameters more efficiently than experiment.

Model Implementation

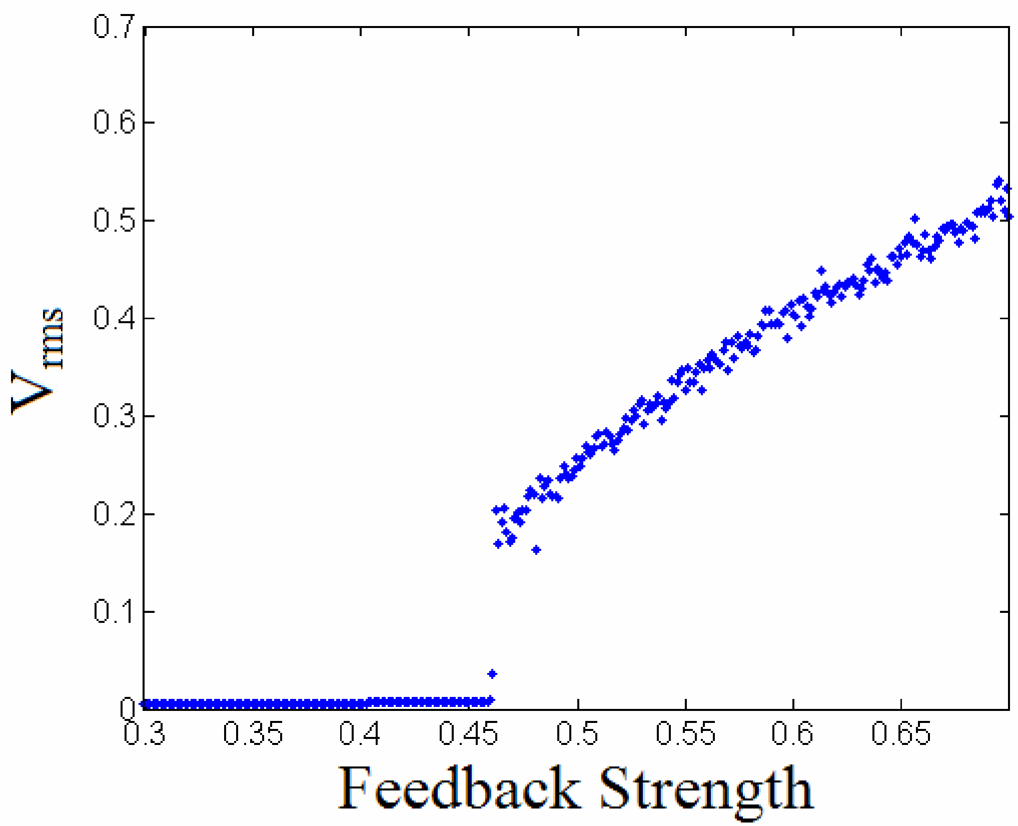
- The nonlinearities of the laser combined with the delayed feedback creates complex and fascinating behavior.
- Using MATLAB, we implemented a fourth order Runge-Kutta integration method for the delayed differential equations.
- We apply the low and high pass filters in the time domain, using a first order differential equation to describe each one.
- After matching parameters of the model to the characteristics of the laser, we vary the feedback strength and the time delay.

Layers of Behavior



- of the total delay.

Results



- We measure the amplitude of oscillation of the time series by using V_{rms}.
- Oscillations begin for a self coupling strength above a specific threshold, as found in experiment.

Conclusions and Future Work

- Dynamics of the system depend greatly on the feedback strength and the time delay.
- We found a qualitative agreement between simulations and experiment.
- Further explore the physical cause of the pulsing on the microsecond timescale.
- Increase the order of the filters to better match experimental filters.
- Increase the number of lasers in the model.