Communication using Synchronized Chaotic Systems

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Introduction

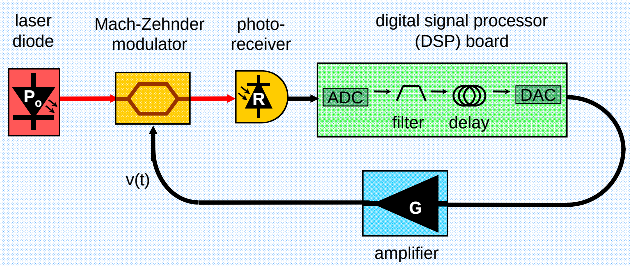
• Two optoelectronic chaotic oscillators may synchronize when coupled together

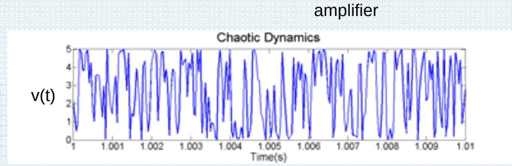
• Chaotic synchronization has attracted attention for uses in secure communications

• Such systems are sensitive to perturbations in the communication channel

• We explore the benefits of implementing an adaptive strategy on a chaotic communication system

Mach-Zehnder Feedback Loop



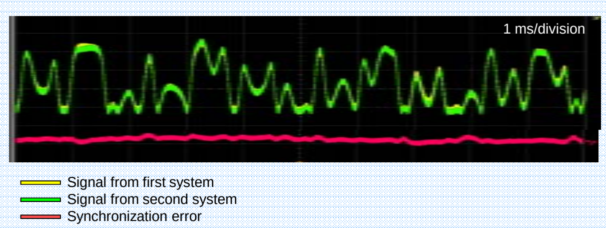


• A closed feedback loop with nonlinearity and time delay will produce a chaotic signal

• A pair of these systems can exhibit synchronous behavior

• Parameters in each loop must be matched or very similar for synchronization

• How well they synchronize depends on how closely their parameters are matched



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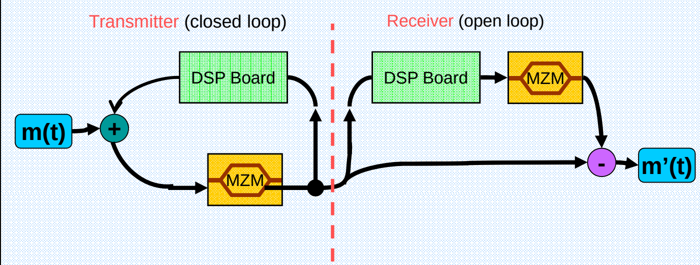
Communication

The phenomenon of synchronization may be exploited to recover a masked message from a chaotic transmitter.

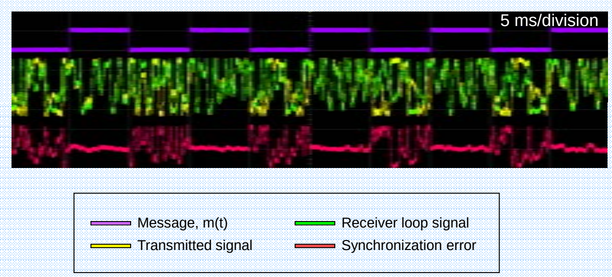


When a digital message is sent as an added modulation,

• Sending "zero" causes no change; systems stay in sync

• Sending "one" creates mismatch between parameters of the transmitter and receiver loops; systems go out of synchrony

• The difference between the signals from the two loops (shown in pink below) can be rectified to reconstruct the original message



Communication in the presence of Channel Disturbance

• Communications systems are sensitive to perturbations in the communication channel

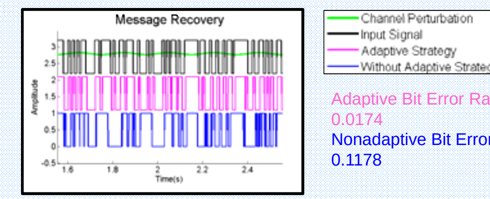
• An adaptive strategy has been developed to track, compensate for, and maintain synchrony in the presence of channel disturbances [1]

• We explore the potential benefits of using such an adaptive strategy on a communication system

[1] Ravoori et al. "Adaptive Synchronization for Coupled Chaotic Oscillators" submitted to Phys. Rev. Lett. arxiv.org/ftp/arxiv/papers/0907/0907.3894.pdf

Adaptive Synchronization

A pseudorandom bit sequence is transmitted over a time-varying communication channel. We examine cases with and without the adaptive strategy implemented.

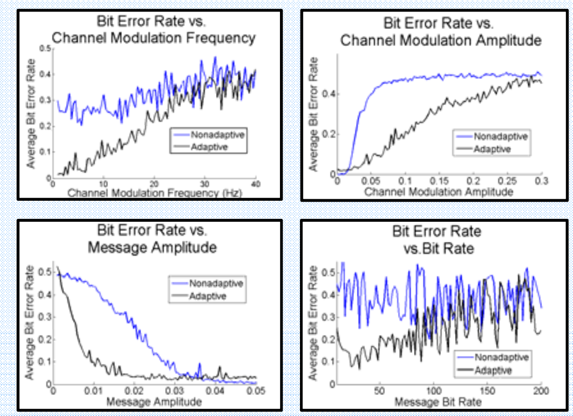


Adaptive Bit Error Rate: 0.0174

Nonadaptive Bit Error Rate: 0.1178

Bit error rate improved by a factor of ten.

We simulate how the bit error rate is improved by the adaptive strategy.



Conclusions

• Demonstrated communication with optoelectronic feedback loop including DSP

•Discovered the adaptive synchronization scheme can improve communication bit error rates when the communication channel is perturbed

Future Work

• Experimentally validate the results of the numerical simulations performed

• Further investigate parameter regimes for which the adaptive strategy improves recovery