Detecting the position and strength of attenuating elements in a small network

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Inferring network properties from the dynamics of the nodes in a network is both a challenging task and of growing importance for applied network science. A subset of this broad question is: how do we determine changes in coupling strengths between the elements (link weights) in a fixed network topology? We propose a method to simultaneously determine (1) which link is affected and (2) by how much when one of the coupling strengths in a small network of unsynchronized dynamical nodes is altered. After proper calibration, realizing this method involves only measurements of the dynamical features of a single node, such as the maximum and minimum signal amplitudes or time-delay signatures (peaks) in the signal's autocorrelation function. We have also investigated ways to decrease the uncertainty in detecting both the position and strength of the attenuating element. We find that a node has enhanced sensing performance when it has: self-feedback, chaotic (rather than stochastic) dynamics, and parameter mismatch with respect to the other nodes in the network. We demonstrate experimentally our method using a network of optoelectronic oscillators (OEOs) operating in a high-speed and broadband chaotic regime [1]. We plan to extend this method to the design of an intrusion detection system, where several OEOs are spread around a scene and wirelessly coupled via antennas. The ultra-wide-band signals emitted by the nodes can pass through building materials with little attenuation, but would be strongly attenuated by a person who enters the path between two nodes. We expect that by monitoring the dynamics of one or more of the OEOs our method would be able to determine both the presence and approximate location of the intruder.

[1] K. E. Callan, *et al.*, *Phys. Rev. Lett.* **104**, 113901 (2010).