Livestock disease spread through animal movements: a temporal network approach

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Livestock trade forms a network of agricultural holdings connected via trade of live animals. These networks are often treated as static objects, although trade is in fact strongly time-dependent. This has a dramatic impact on the possible spreading patterns for infectious diseases.
A static (aggregated) trade network is constructed as follows: if two nodes are connected directly to each other in a time-dependent network, the same connection is present in the static network. A fundamental difference between the static and the time dependent view however, is the consideration of paths, i.e. indirect connections over more than one edge. Concerning paths, the causality of the edges used plays an essential role. In an aggregated network, paths can seem causal, although they do not follow a time-respecting sequence of edges in the real system. This leads to a systematic overestimation of outbreak sizes, if trade networks are treated as static.
We introduce a new method, which allows for the computation of the total causal path structure of a temporal network using the adjacency matrices of its snapshots. In addition, information about the timescales required for path traversal can be derived from the step-by-step derivation of accessibility. This procedure directly yields the distribution of shortest path durations in a temporal network. In addition, we define the new measure causal fidelity that compares the number of paths in a temporal network with its aggregated counterpart. The methods presented here require only basic knowledge linear algebra and can be implemented efficiently. Their capability is demonstrated for livestock trade networks in Germany.
Literature: H Lentz, T Selhorst, and I Sokolov, Phys. Rev. Lett., 2013.