Synergy and redundancy of dynamical networks

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We analyze, by means of Granger causality (GC), the effect of synergy and redundancy in the inference (from time series data) of the information flow between subsystems of a complex dynamical network. While we show that fully conditioned GC (CGC) is not affected by synergy, the pairwise analysis fails to prove synergetic effects. In cases when the number of samples is low, thus making the fully conditioned approach unfeasible, we show that partially conditioned GC (PCGC) is an effective approach if the set of conditioning variables is properly chosen. Here we consider two different strategies (based either on informational content for the candidate driver or on selecting the variables with highest pairwise influences) for PCGC and show that, depending on the data structure, either one or the other might be equally valid. On the other hand, we observe that fully conditioned approaches do not work well in the presence of redundancy, thus suggesting the strategy of separating the pairwise links in two subsets: those corresponding to indirect connections of the CGC (which should thus be excluded) and links that can be ascribed to redundancy effects and, together with the results from the fully connected approach, provide a better description of the causality pattern in the presence of redundancy.

References:
Sebastiano Stramaglia, Jesus M. Cortes, Daniele Marinazzo. Synergy and redundancy in the Granger causal analysis of dynamical networks. New Journal of Physics 16: 105003, 2014