Causal influence in the Linear Response Model

Andrea Auconi, Edda Klipp

Theoretical Biophysics, Humboldt-Universität zu Berlin, Berlin, Germany;
Computational Systems Biology, Humboldt-Universität zu Berlin, Berlin, Germany

Within the framework of stochastic differential equations, I am developing a quantitative definition of causal influence based on information flows. This measure is strongly related to the concept of redundancy whose intuition we may have in an analytical model of linear response to continuous fluctuations, the Linear Response Model. In particular, mapping a dynamical system into the point-to-point communication scheme of Information Theory, I developed a redundancy measure based on the mutual information between sources and on how they interact to give the output. Given this measure we obtain a definition of the Unique (non-redundant) Information that has properties reminiscent of our intuition of causal influence, conceived as a quantification of the effects of causality over time. We used this definition as a tool for model-independent network reconstruction in experimental data of transcription factors and mRNA concentrations, and just looking at the fluctuations in a wild type cell during cell cycle we were able to detect some already well-established molecular interactions.