Information flows and their role in data analysis

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Abstract

Complex dynamical system is a system composed of several subsystems (with given properties) interacting between each other and surrounding environment. These interactions brings to the whole system new properties, absent in composing parts. Very important question that arises in this topic is why by the "adding" several parts together we obtain something completely different. If we want to answer this question, we must turn our attention to the composing part, i.e. the way how subsystems interact within each other, how are they connected and what are the relationships between them.

The fundamental aspect in understanding a complex system is determining its structure, especially causality dynamics between different parts of a system - *information flows*. It is desirable to know what mechanisms generate information, where is that information stored, and how is it transmitted within a system. Information flows might be possible between structures on a one scale, or from the micro- to the macro-scales. *Transfer entropies*, directional measure of uncertainty, appeared to be a useful tool for measuring non-linear information flows between or within the systems.

In the following work we present an intuitive derivation of the family of α-entropies resulting with a concept of so called *Rényi transfer α-entropies*. The latter is able to selectively emphasize certain parts of probability distributions. That is a favourable property in analyzing processes, where marginal parts are the main source of the relevant information. First, we use the derived methods to study model systems as *Lorenz attractor*, and then we show the application on the real data from financial markets. Results show, that the Rényi transfer entropies can detect information flows between processes, but yet it is hard to call them causal in Granger terms.