Determining the net direction of information flow in mutually coupled non-identical chaotic oscillators

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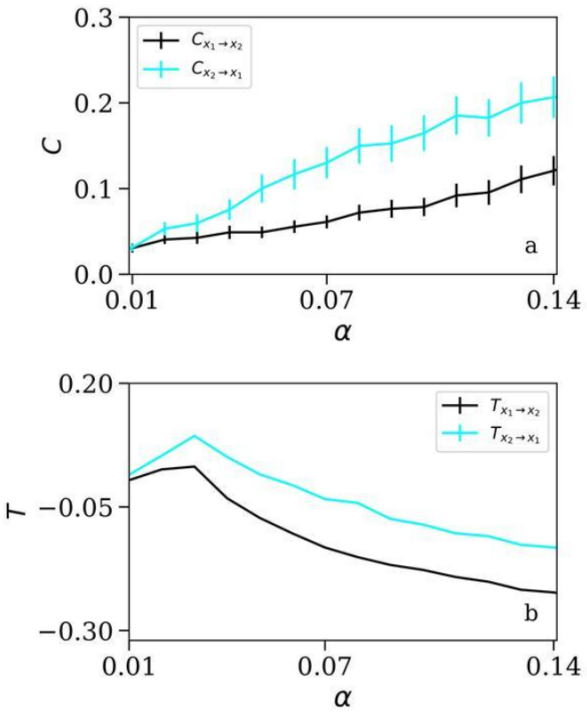

In coupled oscillator models with unidirectional coupling, identifying the driver and driven relationship is pretty straightforward: information is transferred from the driving oscillator to the driven oscillator. This driver-driven concept, however, does not apply to mutual (or bidirectional) coupling. This project specifically addresses this issue. More explicitly, we have focused on one of the fundamental questions in a coupled chaotic oscillator framework: What is the direction of net information transfer in mutually coupled non-identical chaotic oscillators? It is indeed a fundamental inquiry in the coupled oscillator model framework. To address this, we have adopted a particular form of conditional mutual information (CMI), an asymmetric and model-free index, to quantify the amount of information transferred from one oscillator to the other. Furthermore, we have defined the maximum Lyapunov exponent as a quantitative measure of the 'degree of chaos' in an isolated chaotic system. Our findings demonstrate a consistent trend: a pronounced net information transfer from the oscillator exhibiting a higher degree of chaos to the other. In order to understand the net information flow, we have computed the projected Kolmogorov-Sinai (KS) entropies of variables from interacting oscillators at different values of the control parameter (coupling strength, α). It has been established that the variable exhibiting higher projected KS entropy transmits more information to the other. We have ascertained the broad applicability of our findings by considering two categories of coupled 'non-identical' oscillators: In the first category, the functional forms of both oscillators are identical, with a disparity observed in one parameter value. An additional measure, the Liang information flow, has been incorporated to support the generality of our results. In the second category, the functional forms of the oscillators are entirely distinct from one another. We have further expanded our investigation by examining the effectiveness of CMI in determining the net information direction in coupled oscillator models, where the interacting oscillators have different phase-space dimensions. These thorough analyses enable us to draw conclusions that remain valid across various conditions, ensuring the robustness of our results.

References:

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