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Predictability Beyond Memory Loss: Retrieving Synergistic and Coevolutionary Information among Statistically Independent Processes

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There is a common misconception that statistically independent processes cannot share any information, with statistical memory loss believed to dictate the end of predictability. In reality, the absence of statistical links does not preclude the existence of physical interactions embodying a dynamic structure with additional predictability.

In order to bring out and characterize that hidden information in complex systems, generalized information-theoretical measures are hereby formulated in terms of fundamental dynamic interactions in nonlinear statistical mechanics, following recent advances in theoretical physics (Perdigão, 2018).

These novel measures bring out additional sources of synergistic and redundant information emerging from microphysical interactions such as in synergistic and coevolutionary settings, even if the statistical distributions are factorable.

With these theoretical developments at hand, hidden information is hereby retrieved from within intricate dynamic complexity, to unveil new sources of system understanding and predictability – including for systems that appear to behave in a completely memoryless random manner without a discernible deterministic core.
In doing so, elusive predictability is found and explicitly quantified even beyond post-critical spatiotemporal memory loss, long after nonlinear multi-information fades away.

The retrieval and quantification of predictive power is further achieved for perennially transient settings where there is no recurrence, no reference attractor, no thermodynamic optimality to be realistically reached. In doing so, these advances enable statistic-dynamic analysis and prediction in extremely adverse conditions where the traditional nonlinear sciences had no solution.
The collapse of dynamic regimes and nonlinear memory in far-from-equilibrium non-ergodic dynamics is thus no longer an obstacle for system understanding and prediction.

In the realm of methodological applications, new paradigms are hereby formulated in the data analysis and dynamic model design of complex systems, including the formulation of rigorous solutions for the prediction of unprecedented criticalities. This provides decision support in anticipation of events that until now were perceived as unpredictable.

Fundamentally, the findings open a new chapter in nonlinear statistics, nonlinear dynamics and information theory, where fundamental physics comes into play to shed light into the mysteries of complexity.

Reference:
Perdigão, Rui A. P. (2018): Polyadic Entropy, Synergy and Redundancy among Statistically Independent Processes in Nonlinear Statistical Physics with Microphysical Codependence. Entropy 2018, 20(1), 26; doi:10.3390/e20010026.