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Section Information

This section, focuses on original and new research results regarding this broad and deep mathematical theory, as well as in diverse applications. Thus, manuscripts on source coding, channel coding, algorithmic complexity theory, algorithmic information theory, information–theoretic security, and measures of information, as well as on their application to traditional as well as novel scenarios are solicited. Submissions addressing critical up-to-date reviews will also be welcome.

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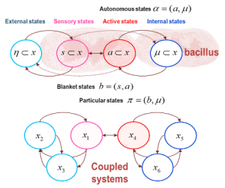
Section Information Theory, Probability and Statistics

Featured Papers

DOI:10.3390/e23091220

Stochastic Chaos and Markov Blankets

Authors: Karl Friston, Conor Heins, Kai Ueltzhöffer, Lancelot Da Costa and Thomas Parr

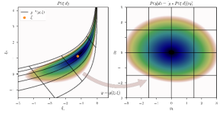


Abstract: In this treatment of random dynamical systems, we consider the existence—and identification—of conditional independencies at nonequilibrium steady-state. These independencies underwrite a particular partition of states, in which internal states are statistically secluded from external states by blanket states. The existence of such partitions has interesting implications for the information geometry of internal states. In brief, this geometry can be read as a physics of sentience, where internal states look as if they are inferring external states. However, the existence of such partitions—and the functional form of the underlying densities—have yet to be established. Here, using the Lorenz system as the basis of stochastic chaos, we leverage the Helmholtz decomposition—and polynomial expansions—to parameterise the steady-state density in terms of surprisal or self-information. We then show how Markov blankets can be identified—using the accompanying Hessian—to characterise the coupling between internal and external states in terms of a generalised synchrony or synchronisation of chaos. We conclude by suggesting that this kind of synchronisation may provide a mathematical basis for an elemental form of (autonomous or active) sentience in biology.

DOI:10.3390/e23070853

Geometric Variational Inference

Authors: Philipp Frank, Reimar Leike and Torsten A. Enßlin

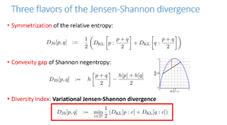


Abstract: Efficiently accessing the information contained in non-linear and high dimensional probability distributions remains a core challenge in modern statistics. Traditionally, estimators that go beyond point estimates are either categorized as Variational Inference (VI) or Markov-Chain Monte-Carlo (MCMC) techniques. While MCMC methods that utilize the geometric properties of continuous probability distributions to increase their efficiency have been proposed, VI methods rarely use the geometry. This work aims to fill this gap and proposes geometric Variational Inference (geoVI), a method based on Riemannian geometry and the Fisher information metric. It is used to construct a coordinate transformation that relates the Riemannian manifold associated with the metric to Euclidean space. The distribution, expressed in the coordinate system induced by the transformation, takes a particularly simple form that allows for an accurate variational approximation by a normal distribution. Furthermore, the algorithmic structure allows for an efficient implementation of geoVI which is demonstrated on multiple examples, ranging from low-dimensional illustrative ones to non-linear, hierarchical Bayesian inverse problems in thousands of dimensions.

DOI:10.3390/e23040464

On a Variational Definition for the Jensen-Shannon Symmetrization of Distances Based on the Information Radius

Author: Frank Nielsen

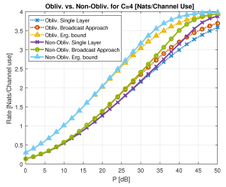


Abstract: We generalize the Jensen-Shannon divergence and the Jensen-Shannon diversity index by considering a variational definition with respect to a generic mean, thereby extending the notion of Sibson's information radius. The variational definition applies to any arbitrary distance and yields a new way to define a Jensen-Shannon symmetrization of distances. When the variational optimization is further constrained to belong to prescribed families of probability measures, we get relative Jensen-Shannon divergences and their equivalent Jensen-Shannon symmetrizations of distances that generalize the concept of information projections. Finally, we touch upon applications of these variational Jensen-Shannon divergences and diversity indices to clustering and quantization tasks of probability measures, including statistical mixtures.

DOI:10.3390/e23010120

The Broadcast Approach in Communication Networks

Authors: Ali Tajer, Avi Steiner and Shlomo Shamai (Shitz)



Abstract: In this paper we review the theoretical and practical principles of the broadcast approach to communication over state-dependent channels and networks in which the transmitters have access to only the probabilistic description of the time-varying states while remaining oblivious to their instantaneous realizations. When the temporal variations are frequent enough, an effective long-term strategy is adapting the transmission strategies to the system's ergodic behavior. However, when the variations are infrequent, their temporal average can deviate significantly from the channel's ergodic mode, rendering a lack of instantaneous performance guarantees. To circumvent a lack of short-term guarantees, the broadcast approach provides principles for designing transmission schemes that benefit from both short- and long-term performance guarantees. This paper provides an overview of how to apply the broadcast approach to various channels and network models under various operational constraints.