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Section Information

Biology and medicine, from molecules to landscapes, are ideally suited to entropy or information approaches, because biological systems are highly variable, with stochastic processes:

- Innovation (mutation, epigenetics, recombination, speciation)
- Transmission of information (transcription, translation, reproduction, learning)
- Adaptation (natural and sexual selection, behaviour)
- Movement (molecules, gametes, seeds, individuals)

The Entropy and Biology Section aims to publish:

- Articles that highlight how entropic approaches are addressing an impressive array of questions, from molecular biology to landscape ecology and biomedicine
- New entropic approaches in biology
- Reviews that guide the biological use of novel entropic approaches.

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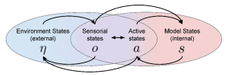
Section Entropy and Biology

Featured Papers

DOI:10.3390/e24020301

The Free Energy Principle for Perception and Action: A Deep Learning Perspective

Authors: Pietro Mazzaglia, Tim Verbelen, Ozan Çatal and Bart Dhoedt

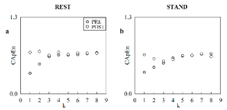


Abstract: The free energy principle, and its corollary active inference, constitute a bio-inspired theory that assumes biological agents act to remain in a restricted set of preferred states of the world, i.e., they minimize their free energy. Under this principle, biological agents learn a generative model of the world and plan actions in the future that will maintain the agent in an homeostatic state that satisfies its preferences. This framework lends itself to being realized in silico, as it comprehends important aspects that make it computationally affordable, such as variational inference and amortized planning. In this work, we investigate the tool of deep learning to design and realize artificial agents based on active inference, presenting a deep-learning oriented presentation of the free energy principle, surveying works that are relevant in both machine learning and active inference areas, and discussing the design choices that are involved in the implementation process. This manuscript probes newer perspectives for the active inference framework, grounding its theoretical aspects into more pragmatic affairs, offering a practical guide to active inference newcomers and a starting point for deep learning practitioners that would like to investigate implementations of the free energy principle.

DOI:10.3390/e24010080

Monitoring the Evolution of Asynchrony between Mean Arterial Pressure and Mean Cerebral Blood Flow via Cross-Entropy Methods

Authors: Alberto Porta et al.

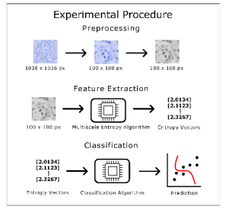


Abstract: Cerebrovascular control is carried out by multiple nonlinear mechanisms imposing a certain degree of coupling between mean arterial pressure (MAP) and mean cerebral blood flow (MCBF). We explored the ability of two nonlinear tools in the information domain, namely cross-approximate entropy (CApEn) and cross-sample entropy (CSampEn), to assess the degree of asynchrony between the spontaneous fluctuations of MAP and MCBF. CApEn and CSampEn were computed as a function of the translation time. The analysis was carried out in 23 subjects undergoing recordings at rest in supine position (REST) and during active standing (STAND), before and after surgical aortic valve replacement (SAVR). We found that at REST the degree of asynchrony raised, and the rate of increase in asynchrony with the translation time decreased after SAVR. These results are likely the consequence of the limited variability of MAP observed after surgery at REST, more than the consequence of a modified cerebrovascular control, given that the observed differences disappeared during STAND. CApEn and CSampEn can be utilized fruitfully in the context of the evaluation of cerebrovascular control via the noninvasive acquisition of the spontaneous MAP and MCBF variability.

DOI:10.3390/e23101303

Parameter Analysis of Multiscale Two-Dimensional Fuzzy and Dispersion Entropy Measures Using Machine Learning Classification

Authors: Ryan Furlong, Mirvana Hilal, Vincent O'Brien and Anne Humeau-Heurtier

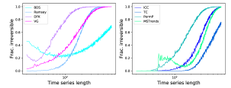


Abstract: Two-dimensional fuzzy entropy, dispersion entropy, and their multiscale extensions ($MF_{uzzy}En_{2D}$ and $MD_{isp}En_{2D}$, respectively) have shown promising results for image classifications. However, these results rely on the selection of key parameters that may largely influence the entropy values obtained. Yet, the optimal choice for these parameters has not been studied thoroughly. We propose a study on the impact of these parameters in image classification. For this purpose, the entropy-based algorithms are applied to a variety of images from different datasets, each containing multiple image classes. Several parameter combinations are used to obtain the entropy values. These entropy values are then applied to a range of machine learning classifiers and the algorithm parameters are analyzed based on the classification results. By using specific parameters, we show that both $MF_{uzzy}En_{2D}$ and $MD_{isp}En_{2D}$ approach state-of-the-art in terms of image classification for multiple image types. They lead to an average maximum accuracy of more than 95% for all the datasets tested. Moreover, $MF_{uzzy}En_{2D}$ results in a better classification performance than that extracted by $MD_{isp}En_{2D}$ as a majority. Furthermore, the choice of classifier does not have a significant impact on the classification of the extracted features by both entropy algorithms. The results open new perspectives for these entropy-based measures in textural analysis.

DOI:10.3390/e23111474

Algorithmic Approaches for Assessing Irreversibility in Time Series: Review and Comparison

Authors: Massimiliano Zanin and David Papo



Abstract: The assessment of time irreversibility, i.e., of the lack of invariance of the statistical properties of a system under the operation of time reversal, is a topic steadily gaining attention within the research community. Irreversible dynamics have been found in many real-world systems, with alterations being connected to, for instance, pathologies in the human brain, heart and gait, or to inefficiencies in financial markets. Assessing irreversibility in time series is not an easy task, due to its many aetiologies and to the different ways it manifests in data. It is thus not surprising that several numerical methods have been proposed in the last decades, based on different principles and with different applications in mind. In this contribution we review the most important algorithmic solutions that have been proposed to test the irreversibility of time series, their underlying hypotheses, computational and practical limitations, and their comparative performance. We further provide an open-source software library that includes all tests here considered. As a final point, we show that "one size does not fit all", as tests yield complementary, and sometimes conflicting views to the problem; and discuss some future research avenues.