

Article

Rényi Cross-Entropy Measures for Common Distributions and Processes with Memory

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Abstract: Two Rényi-type generalizations of the Shannon cross-entropy, the Rényi cross-entropy and the Natural Rényi cross-entropy, were recently used as loss functions for the improved design of deep learning generative adversarial networks. In this work, we derive the Rényi and Natural Rényi differential cross-entropy measures in closed form for a wide class of common continuous distributions belonging to the exponential family, and we tabulate the results for ease of reference. We also summarise the Rényi-type cross-entropy rates between stationary Gaussian processes and between finite-alphabet time-invariant Markov sources.

Keywords: Rényi information measures; cross-entropy; divergence measures; exponential family distributions; Gaussian processes; Markov sources

1. Introduction

The Rényi entropy [1] of order α of a probability mass function p with finite support S is defined as

$$H_\alpha(p) = \frac{1}{1-\alpha} \ln \sum_{x \in S} p(x)^\alpha \quad (1)$$

for $\alpha > 0, \alpha \neq 1$. The Rényi entropy generalizes the Shannon entropy,

$$H(p) = - \sum_{x \in S} p(x) \ln p(x), \quad (2)$$

in the sense that as $\alpha \rightarrow 1$, $H_\alpha(p) \rightarrow H(p)$. Several other Rényi-type information measures have been put forward, each obeying the condition that their limit as α goes to one reduces to a Shannon-type information measure. This includes the Rényi divergence (of order α) between two discrete distributions p and q with common finite support S , given by

$$D_\alpha(p||q) = \frac{1}{\alpha-1} \ln \sum_{x \in S} p(x)^\alpha q(x)^{1-\alpha} \quad (3)$$

which reduces to the familiar Kullback–Leibler divergence,

$$D_{\text{KL}}(p||q) = \sum_{x \in S} p(x) \ln \frac{p(x)}{q(x)}, \quad (4)$$

as $\alpha \rightarrow 1$. Note that in some cases [2], there may exist multiple Rényi-type generalisations for the same information measure (particularly for mutual information).

Many of these definitions admit natural counterparts in the case when the involved distributions have a probability density function (pdf). This gives rise to information measures such as the Rényi differential entropy for pdf p with support S ,

$$h_\alpha(p) = \frac{1}{1-\alpha} \ln \int_S p(x)^\alpha dx. \quad (5)$$



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