Accepted Manuscript

Surrogate data for hypothesis testing of physical systems

Gemma Lancaster, Dmytro Iatsenko, Aleksandra Pidde, Valentina Ticcinelli, Aneta Stefanovska

PII: S0370-1573(18)30134-0
DOI: https://doi.org/10.1016/j.physrep.2018.06.001
Reference: PLREP 2010

To appear in: *Physics Reports*

Accepted date : 1 June 2018

Please cite this article as: G. Lancaster, D. Iatsenko, A. Pidde, V. Ticcinelli, A. Stefanovska, Surrogate data for hypothesis testing of physical systems, *Physics Reports* (2018), https://doi.org/10.1016/j.physrep.2018.06.001

Manuscript

Surrogate data for hypothesis testing of physical systems

Gemma Lancaster[a], Dmytro Iatsenko[b], Aleksandra Pidde[a,c], Valentina Ticcinelli[a], Aneta Stefanovska[a,*]

[a] *Department of Physics, Lancaster University, UK*
[b] *Deutsche Bank, London, UK*
[c] *Department of Information and Communication Technologies, Universitat Pompeu Fabra, Barcelona, Spain*

Abstract

The availability of time series of the evolution of the properties of physical systems is increasing, stimulating the development of many novel methods for the extraction of information about their behavior over time, including whether or not they arise from deterministic or stochastic dynamical systems. Surrogate data testing is an essential part of many of these methods, as it enables robust statistical evaluations to ensure that the results observed are not obtained by chance, but are a true characteristic of the underlying system.

The surrogate data technique is based on the comparison of a particular property of the data (a discriminating statistic) with the distribution of the same property calculated in a set of constructed signals (surrogates) which match the original data set but do not possess the property that is being tested. Fourier transform based surrogates remain the most popular, yet many more options have since been developed to test increasingly varied null hypotheses while characterizing the dynamics of complex systems, including uncorrelated and correlated noise, coupling between systems, and synchronization.

Here, we provide a detailed overview of a wide range of surrogate types, discuss their practical applications and demonstrate their use in both numerically simulated and real experimental systems. We also compare the performance of various surrogate types for the detection of nonlinearity, synchronization and coherence, coupling strength between systems, and the nature of coupling. A MatLab toolbox for many of the surrogate methods is provided.

Keywords: Surrogate data, dynamical systems, time series analysis, complex systems
2010 MSC: 00-01, 99-00

Contents

*Corresponding author