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Surrogation

Theiler, J., Eubank, S., Longtin, A., Galdrikian, B., & Doyne Farmer, J. (1992). Testing for nonlinearity in time series: the method of surrogate data. *Physica D: Nonlinear Phenomena*, *58*(1–4), 77–94. https://doi.org/10.1016/0167-2789(92)90102-S

This is an original citation for using the Algorithm 0, 1 and 2 methods we presented. These methods are hierarchical where 0 is applied first, 1 second and 2 third. Each one steps up the assumption of the data's complexity with 0 hypothesizing the data comes from independent and identically distributed noise. Algorithms 1 and 2 then assume the data has some frequency content of note to account for. These three methods are useful in assessing the quality of a nonlinear analysis.

Schreiber, T., & Schmitz, A. (1996). Improved Surrogate Data for Nonlinearity Tests. *Physical Review Letters*, *77*(4), 635–638. https://doi.org/10.1103/PhysRevLett.77.635

This is an original citation for the Iterative Amplitude Adjusted Fourier Transform method. This method hypothesizes the data comes from a Gaussian linear stochastic process. The improvement over the Amplitude Adjusted Fourier Transform method produces surrogates that have the same autocorrelations and the same probability distribution as the original data but not some of the nonlinear variability. The original method also occasionally produces false positives that are improved on.

Small, M., Yu, D., & G., H. R. (2001). Surrogate Test for Pseudoperiodic Time Series Data. *Physical Revew Letters*, *87*(18). https://doi.org/10.1063/1.1487534

This is an original citation for using Pseudoperiodic Surrogation. This method is appropriate for data with strong periodicity, where the methods by Theiler et al. and Schreiber et al. would be inappropriate. The method creates a state-space from which nearest neighbors are used to reconstruct the time series. This produces surrogates where the short-term dynamics are removed but the long-term dynamics remain.

Nakamura, T., & Small, M. (2005). Small-shuffle surrogate data: Testing for dynamics in fluctuating data with trends. *Physical Review E - Statistical, Nonlinear, and Soft Matter Physics*, *72*(5), 56216. https://doi.org/10.1103/PhysRevE.72.056216

This is an original citation for the small-shuffle method. Similar to Pseudoperiodic Surrogation this method removes the short-term dynamics but preserves the long-term dynamics.

Alkjaer, T., Raffalt, P. C., Dalsgaard, H., Simonsen, E. B., Petersen, N. C., Bliddal, H., & Henriksen, M. (2015). Gait variability and motor control in people with knee osteoarthritis. *Gait and Posture*, *42*(4), 479–484. https://doi.org/10.1016/j.gaitpost.2015.07.063

This publication is a good example of surrogation applied to experimental data. The surrogation help validate the result of the use of Lyapunov Exponents. Surrogation results can sometimes be unwieldly to present. In Figure 3 they were able to compact this information in a readable way nicely.

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