Surrogate Data Analysis

Miguel Xochicale

30th August 2019

THE FOLLOWING PARAGRAPH IS AN EXTRACT FROM
"Chapter 7.2 Future Work: Surrogate Data Analysis"

Non-stationarity and non-linearity of experimental time-series data were assumed in this thesis (see Chapter 1). Such assumption was made based on the ambiguity of nonlinear analysis methods to quantify movement variability and the not yet fully explored area of application of nonlinear analysis methods in human-humanoid interaction (see Chapters 1 and 2). From the examiners of the PhD viva, one recommendation to avoid such prejudice of the type of data is to test the non-linearity and non-stationarity of the experimental time series data before nonlinear analysis methods are applied. Hence, a possible avenue to tackle such caveat is to apply surrogate data analysis to test that data have not been generated by "a stationary Gaussian linear stochastic process that is observed through an invertible, static, but possible linear stochastic function" (Schreiber and Schmitz, 2000, p. 2). However, applying surrogate data analysis to time series data that show strong periodicity or quasi-periodicity might create misleading results and perhaps provide unfair conclusion (see the following figures that illustrate how different realisations of the same periodic sinusoidal signal show to be sometimes stationarity and others non-stationarity). Hence, further research require to be done, perhaps consider the works of Stam et al. (1998) and Small and Tse (2002) to test weak non-stationarity of periodic and quasi-periodic time series data. Also, for future work, it can be considered other time series data from activities that involve more than one joint in order to test the robustness of not only nonlinear analysis methods but also surrogate data analysis.

References

Schreiber, T. and Schmitz, A. (2000). Surrogate time series. *Physica D: Nonlinear Phenomena*, 142(3):346 – 382.

Small, M. and Tse, C. (2002). Applying the method of surrogate data to cyclic time series. *Physica D: Nonlinear Phenomena*, 164(3):187 – 201.

Stam, C., Pijn, J., and Pritchard, W. (1998). Reliable detection of nonlinearity in experimental time series with strong periodic components. *Physica D: Nonlinear Phenomena*, 112(3):361 – 380.

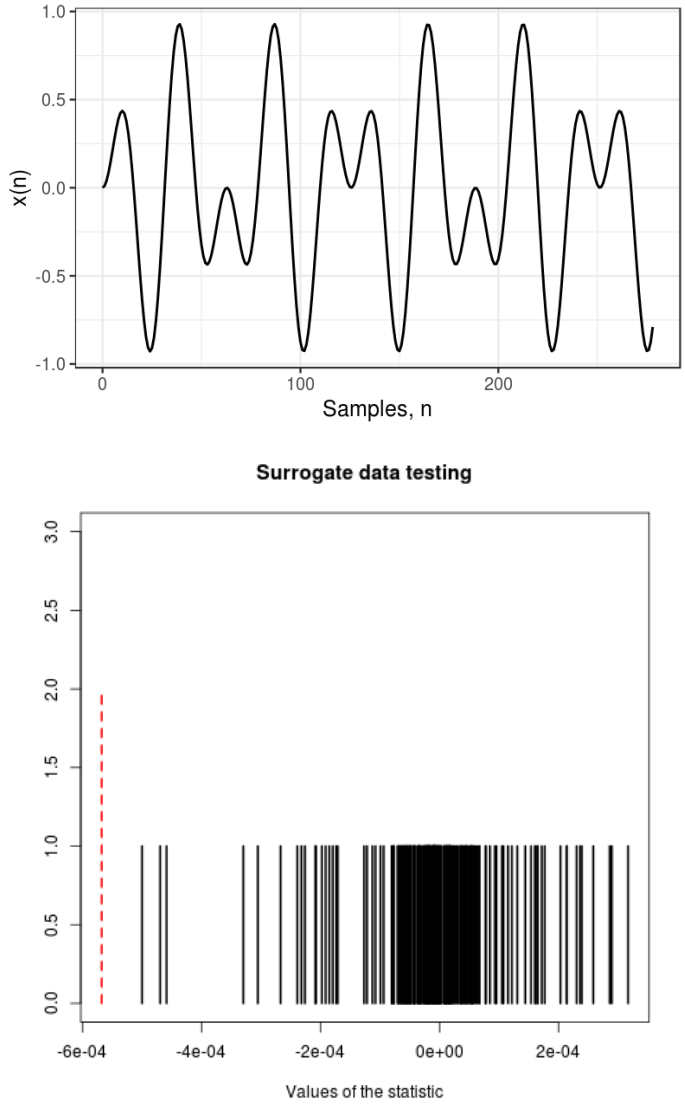

Figure 1: **Realisation 0.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

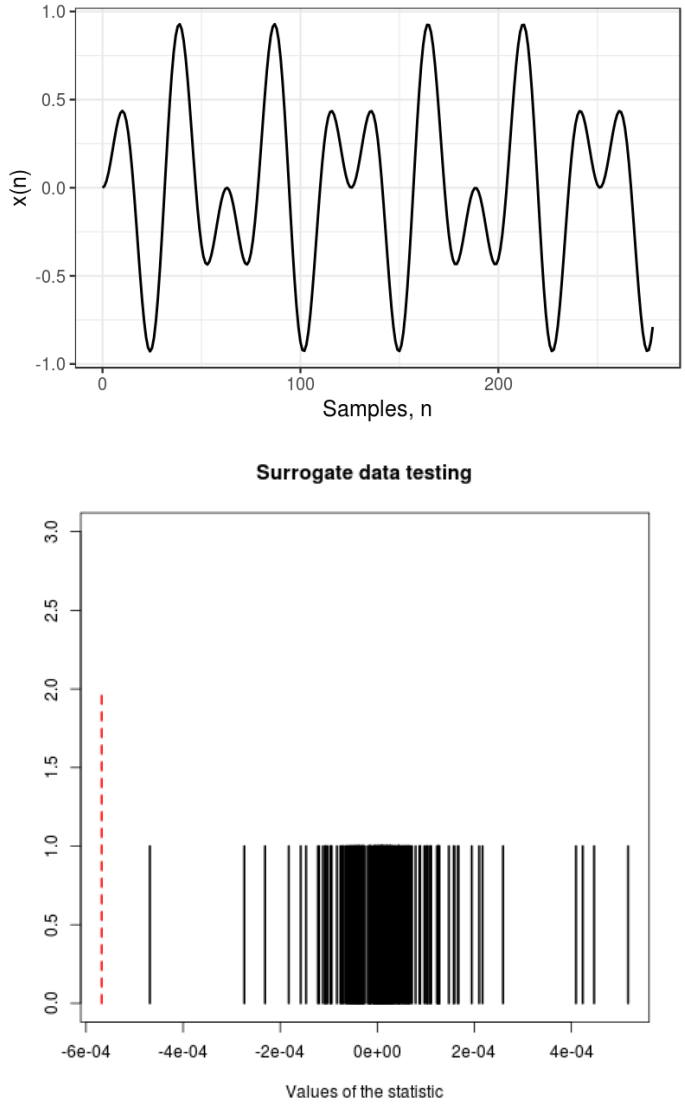

Figure 2: **Realisation 1.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

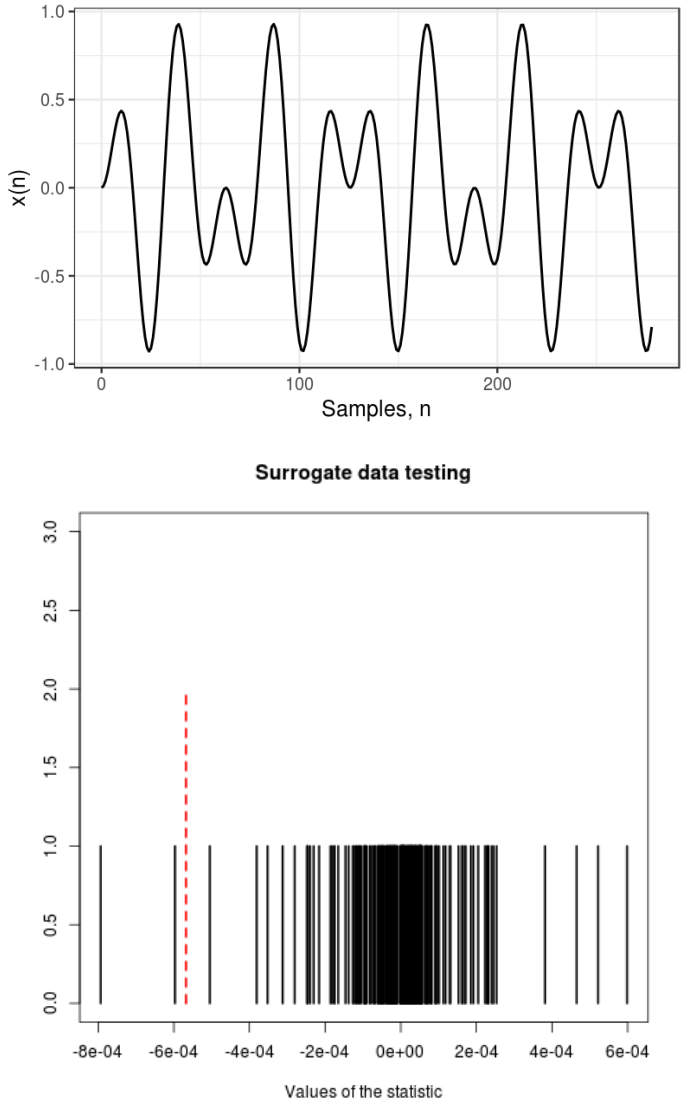

Figure 3: **Realisation 2.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

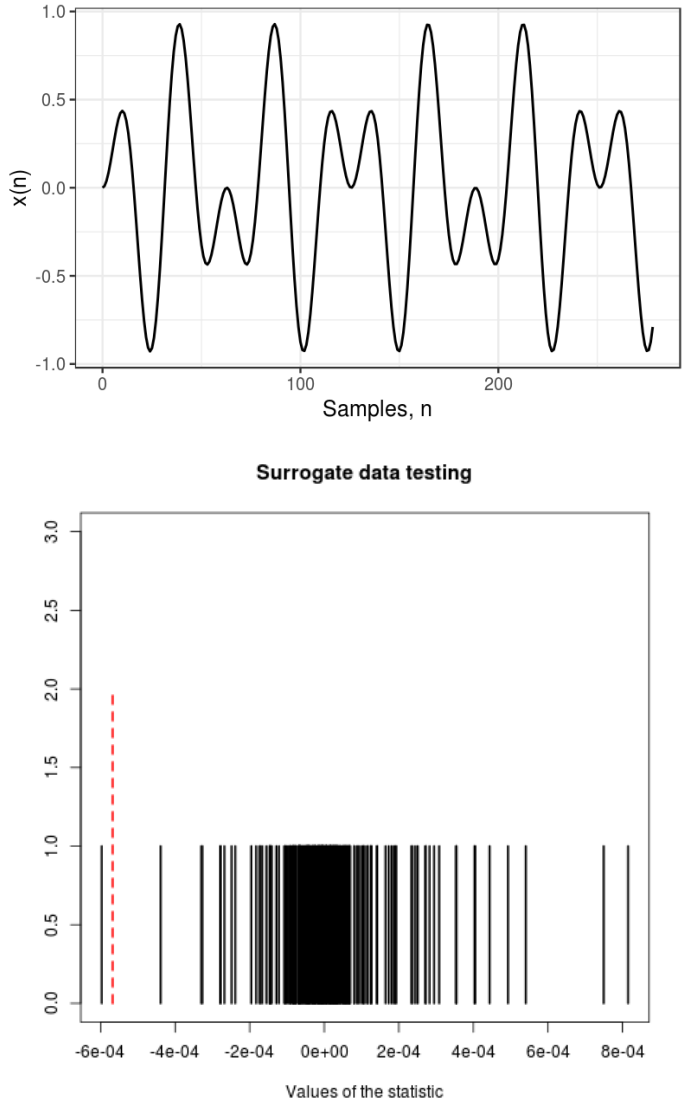

Figure 4: **Realisation 3.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

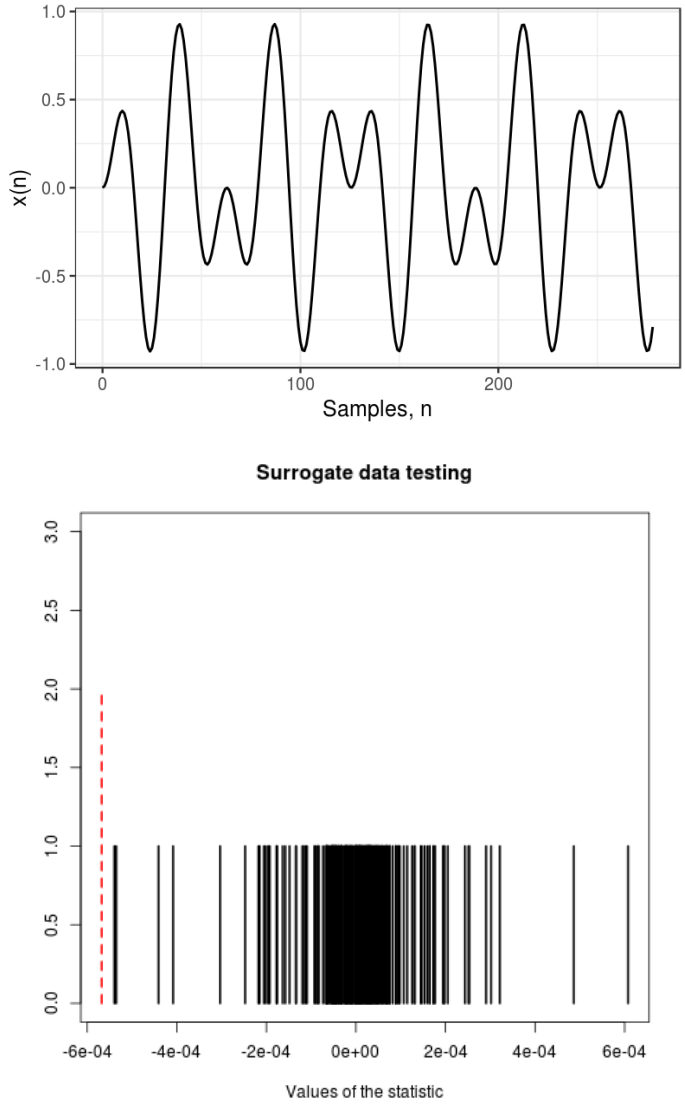

Figure 5: **Realisation 4.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

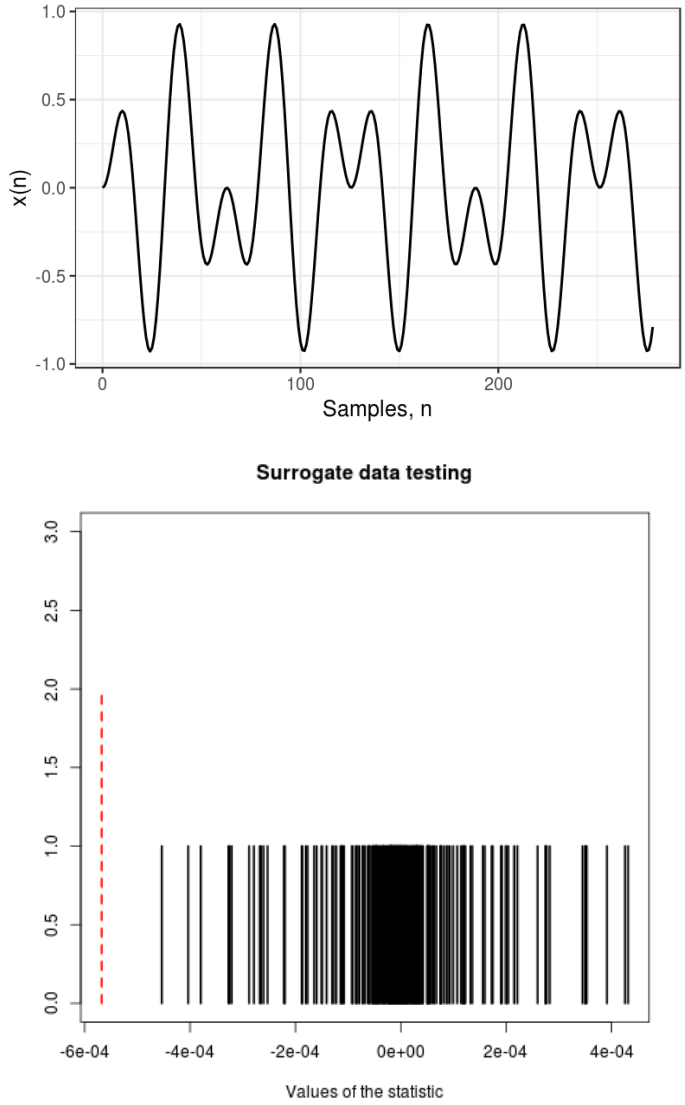

Figure 6: **Realisation 5.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

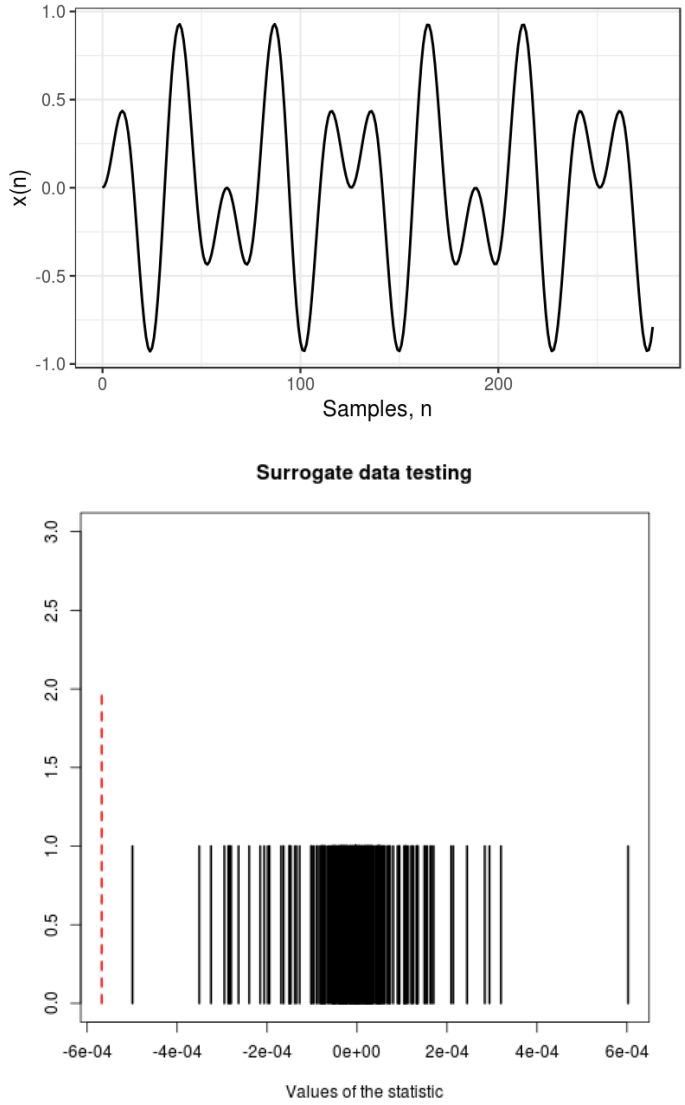

Figure 7: **Realisation 6.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

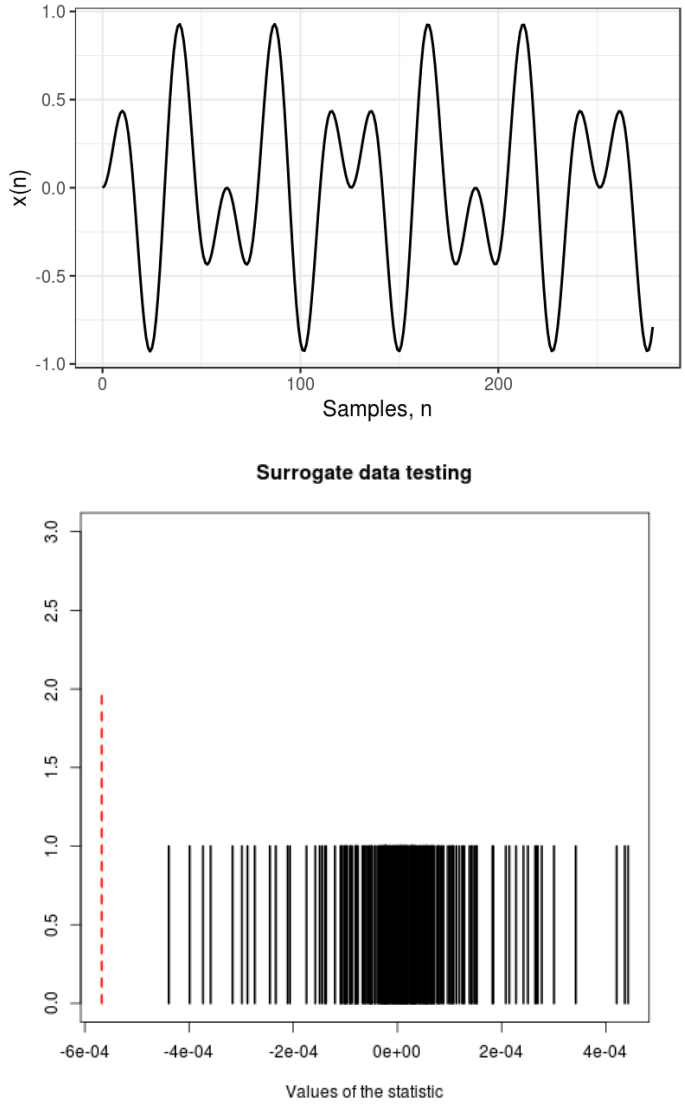

Figure 8: **Realisation 7.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

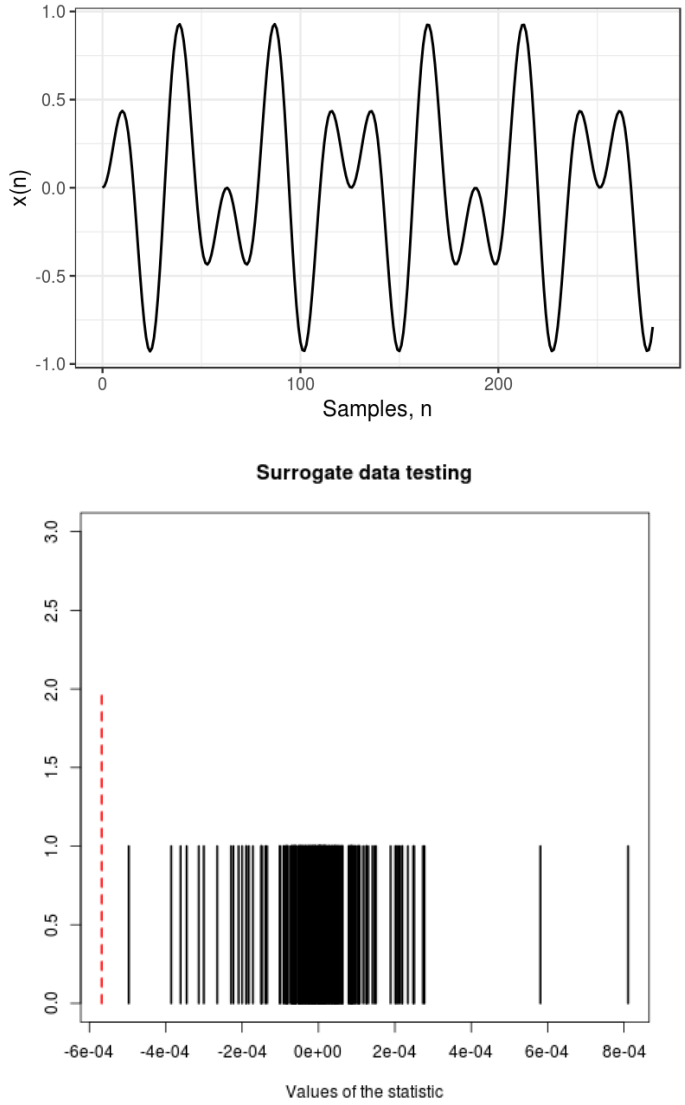

Figure 9: **Realisation 8.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at

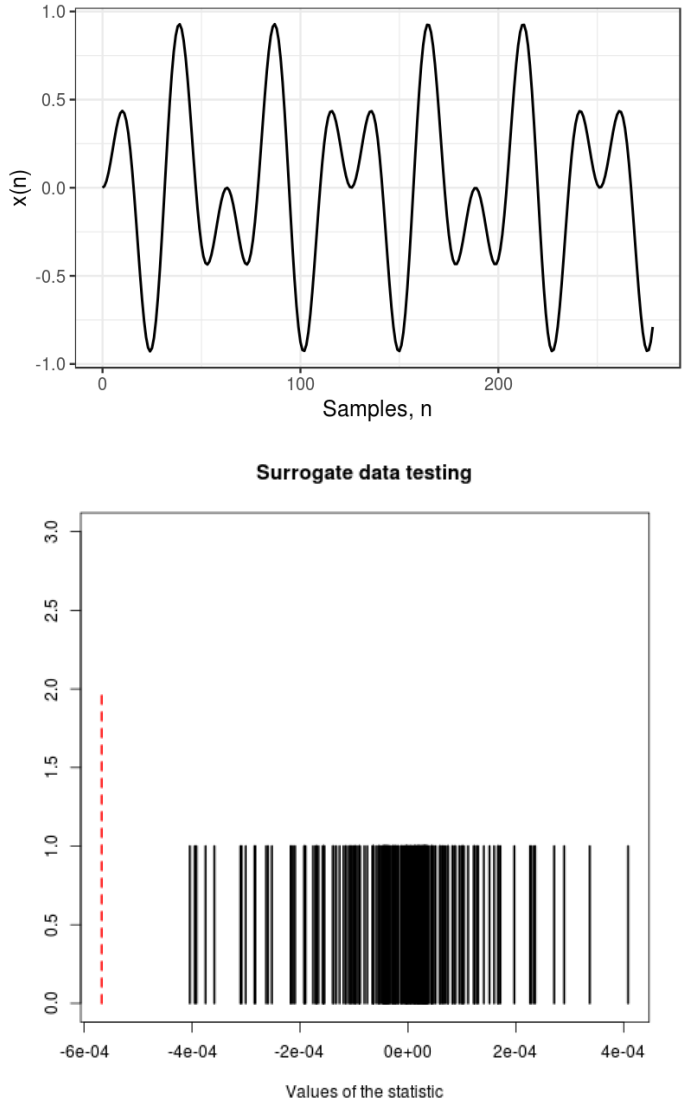

Figure 10: **Realisation 9.** (A) Sinewave time series and (B) surrogate data testing. R code to reproduce the figure is available at