Small, Michael; **Judd, Kevin**

Comparisons of new nonlinear modeling techniques with applications to infant respiration.

(English) Zbl 1041.62523

Physica D 117, No. 1-4, 283-298 (1998).

Summary: This paper concerns the application of new nonlinear time-series modeling methods to recordings of infant respiratory patterns. The techniques used combine the concept of minimum description length modeling with radial basis models. Our first application of the methods produced results that were not entirely satisfactory, particularly with respect to accurately modeling long term quantitative and qualitative features of respiration patterns. This paper describes a number of modifications of the original methods and makes a comparison of the improvements the various modifications gave. The modifications made were increasing the class of basis function, broadening the range of possible embedding strategies, improving the optimization of the likelihood of the model parameters and calculating a closer approximation to description length. The criteria used in the comparisons were description length, root-mean-square prediction error, model size, free-run behavior and amplitude size and variation.

We use surrogate data analysis to confirm the hypothesis that the recorded data are consistent with the nonlinear models we construct, and not consistent with simpler models. We also investigate the free-run dynamics of the model systems to see if the models exhibit features consistent with physiological characteristics observed independently in the respiratory recording. This involved modeling breathing patterns prior to a sigh and onset of a phenomenon called "periodic breathing"; and comparing the period of "cyclic amplitude modulation" of the free-run dynamics of the models and the period of the subsequent periodic breathing observed in respiration recording. The periods were consistent in six out of seven recordings.

MSC:

62P10 Applications of statistics to biology and medical sciences; meta analysis

92C30 Physiology (general)

37N25 Dynamical systems in biology

Keywords:

Radial basis modeling; Description length; Surrogate analysis; Infant respiratory patterns; Periodic breathing

Full Text: DOI

References:

[1] Judd, K.; Mees, A., On selecting models for nonlinear time series, Physica D, 82, 426-444, (1995) · Zbl 0888.58034

[2] M. Small, K. Judd, M. Lowe, S. Stick, Is breathing in infants chaotic? Dimension estimates for respiratory patterns during quiet sleep, J. Appl. Physiol., to appear.

[3] Small, M.; Judd, K.; Stick, S., Linear modelling techniques detect periodic respiratory behaviour in infants during regular breathing in quiet sleep, Am. J. resp. crit. care med., 153, A79, (1996)

[4] Theiler, J.; Eubank, S.; Longtin, A.; Galdrikian, B.; Farmer, J.D., Testing for nonlinearity in time series: the method of surrogate data, Physica D, 58, 77-94, (1992) · Zbl 1194.37144

[5] Small, M.; Judd, K., Detecting nonlinearity in experimental data, Int. J. bifurc. \& chaos, 8, (1998), in press

[6] Kelly, D.H.; Shannon, D.C., Periodic breathing in infants with near-miss sudden infant death syndrome, Pediatrics, 63, 355-360, (1979)

[7] Mendelson, W.B., Human sleep: research and clinical care, (1987), Plenum Medical Book Company

[8] Takens, F., Detecting strange attractors in turbulence, (), 366-381

[9] Abarbanel, H.D.I.; Brown, R.; Sidorowich, J.J.; Tsimring, L.S., The analysis of observed chaotic data in physical systems, Rev. mod. phys., 65, 4, 1331-1392, (1993)

[10] Rissanen, J., Stochastic complexity in statistical inquiry, (1989), World Scientific Singapore · Zbl 0800.68508

[11] Priestly, M.B., Non-linear and non-stationary time series analysis, (1989), Academic Press New York

[12] Kennel, M.B.; Brown, R.; Abarbanel, H.D.I., Determining embedding dimension for phase-space reconstruction using a geo-

metric construction, Phys. rev. A, 45, 3403-3411, (1992)

[13] K. Judd, A. Mees, Embedding as a modeling problem, Physica D, to appear. · Zbl 0965.37061

[14] Schwarz, G., Estimating the dimension of a model, Ann. stat., 6, 461-464, (1978) · Zbl 0379.62005

[15] Theiler, J., On the evidence for low-dimensional chaos in an epileptic electroencephalogram, Phys. lett. A, 196, 335-341, (1995)

[16] Theiler, J.; Rapp, P., Re-examination of the evidence for low-dimensional, nonlinear structure in the human electroencephalogram, Electroencephalogr. clin. neurophysiol., 98, 213-222, (1996)

[17] Theiler, J.; Prichard, D., Constrained-realization Monte-Carlo method for hypothesis testing, Physica D, 94, 221-235, (1996) · Zbl 0888.62087

[18] Judd, K., An improved estimator of dimension and some comments on providing confidence intervals, Physica D, 56, 216-228, (1992) · Zbl 0761.58027

[19] Judd, K., Estimating dimension from small samples, Physica D, 71, 421-429, (1994) · Zbl 0809.62019

[20] Judd, K.; Mees, A., Modeling chaotic motions of a string from experimental data, Physica D, 92, 221-236, (1996) · Zbl 0899.73008