Program to calculate the nonlinear measure (NLM) from time series data

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Description

The program (nlm.c) computes the nonlinear measure from time series data composed of a single dynamical variable. The data set and the parameters have to be provided in two files and the results of the program, namely, deterministic-versus-stochastic (DVS) plot and the nonlinear measure (NLM) are written into two other files (see below).

The algorithm for obtaining the DVS plot has been proposed by M. Casdagli [1] and the nonlinear measure has been calculated from the DVS plot by Tokuda *et. al* [2]. The present program (nlm.c) is the one used in [2].

The input files are:

- parameters.txt : Parameter setting
- data.txt : Single time series data

The output files are:

- dvs_plot.txt : DVS plot
- nlm_value.txt : Nonlinear measure

The file parameters.txt has to contain the following parameters given as plain numbers (ascii), arranged as shown below:

- length: Length of the data set (e.g., 2000, if the data is composed of 2000 points)
- dim: Embedding dimension [2] (e.g., 3 to set the embedding dimension three)

The linked file parameters.txt sets the parameters as length = 2000 and dim = 3 just to show as an example. Please rewrite the parameter file for your own use.

The file data.txt has to contain a series of dynamical data given as real numbers. The linked file data.txt gives a time series data generated from the Lorenz equation to show a sample data file. To apply the program to your own data, please substitute your data file by naming it as data.txt .

When the program is done, two output files are produced.

- The file dvs_plot.txt will contain signal-to-noise ratio and percentage of the number of neighbors. This file can be used to generate the DVS-plot (see Fig. 4, 5(a), 7, 8, 9 of [2]).
- The file nlm_value.txt will contain the NLM outcome.

The above linked output files have been generated by applying the program to the lorenz data (data.txt) with (length, dim) = (2000, 3) to show as an example.

References:

1. M. Casdagli: Chaos and deterministic versus stochastic nonlinear modelling J. R. Stat. Soc. B. 54: 303-328 (1992).
2. I. Tokuda, T. Riede, J. Neubauer, M.J. Owren, H. Herzel: Nonlinear analysis of irregular animal vocalizations, Journal of the Acoustical Society of America 111: 2908-2919 (2002).

Usage

1. Compile the program (nlm.c) with a normal gcc compiler as

   % gcc nlm.c -lm

   The object file can be a.out or any other name like nlm.out as you prefer.

2. Execute the program with

   % a.out

   where the input data file data.txt and the parameter file parameters.txt should be provided as explained in the Description .

3. The program computes the nonlinear measure of the input data and provides the results as

   % Nonlinear Measure = 10.682033 [dB]

   The program also produces an output file dvs_plot.txt , which can be used to display deterministic-versus-stochastic (DVS) plot. Via gnuplot, this can be simply done by

   gnuplot> plot "dvs_plot.txt" w linesp

The program

This part is only important for users who want to modify or understand the code.

Variables (most important ones):

- dim: Embedding dimension
- xx(t): Data field with size length,
- nnn: Number of nearest neighbors to estimate linear predictive coefficients
- step: Incremental step to change the nnn. This decides preciseness of the DVS plot and computational time. Please modify as you wish.
- wd(dim): Linear predictive coefficients

Functions (detailed descriptions in function header):

- SNR: Computation of the signal-to-noise ratio
- NearestNeighbor: Finding nearest neighbors
- LPC_Estimate: Computation of linear predictive coefficients
- Variance: Variance of data
- Quick_Sort: Sorting algorithm

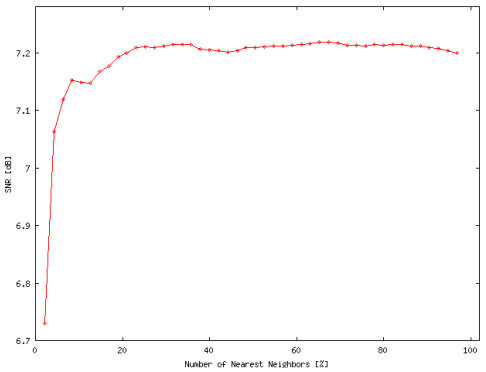
Note

The author is not responsible for any problems or difficulties encountered in implementing or applying this software. Please report problems to Isao Tokuda (i.tokuda@biologie.hu-berlin.de)

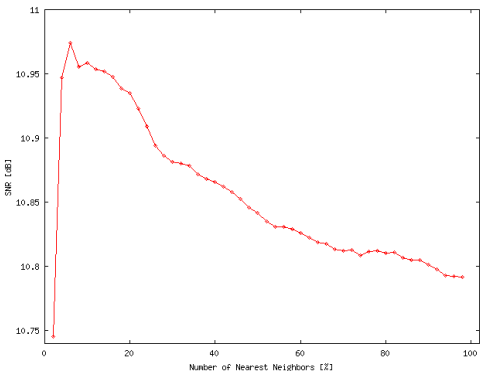
Examples

Examples of applying the program to dog barks are shown below.

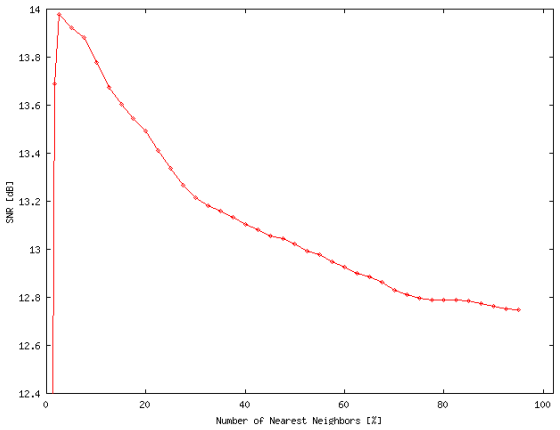
Bark A: Nonlinear Measure = 0.02 [dB]



Bark B: Nonlinear Measure = 0.18 [dB]



Bark C : Nonlinear Measure = 1.23 [dB]



Parameter setting for the above analyses are

- Bark A: length = 1900, dim = 8
- Bark B: length = 2000, dim = 8
- Bark C: length = 1200, dim = 8

Sampling frequency of the three data (a, b, c) is all 20050Hz.