Manual for Horizon for Windows Ver. 1.0.5
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July 14, 1999

This application allows you to calculate the Hurst value for an input time series, if the time series is fractal.

Meaning of the H value

In general, H values close to 0 imply that the time series is highly correlated and "anti-persistent." this means that positive or negative trends in the magnitudes of the values of the time series are very rapidly reversed. The high degree of auto-correlation suggests that the generator of the time series is more complex, or more tightly coupled. H values closer to 0.5 suggest that the autocorrelation of the time series is lost, and the time series begins to resemble a random walk. However, values of H higher than 0.5 imply that the time series again exhibits increasing correlation and trends within the time series are now re-enforced. The time series is said to be "persistent." Heart interbeat interval (IBI) time series tend to have H values between 0 and 0.5. If you find an IBI time series with $H > 0.5$, we'd love to hear about it!

Heart IBI time series are complex in that long-range correlations may be observed over very long periods of recording time. There are "local" values of H, which can be determined down to a resolution of about 100-250 beats, and there are longer-range values of H which may depend on the length of the input time series. We have calculated long range values of H up to 80,000 interbeat intervals. If you look at the local values of H using the "Sliding Windows" feature of the program, you will be surprised to see how much variability exists in the H measure along the time series.

Practically, this means that the input time series should be of about the same length, since otherwise you will be comparing H values along different time scales. This also means that you can calculate an "average" local H value by chopping the time series into appropriate segments. The variance in this local value of H may contain some information regarding the behavior of the signal generator of the time series.

One advantage of the current algorithm is that when tested with synthetic time series of defined spectral slope, the length of the data itself does not alter the calculated value of H. This is not true for analyses carried out in the frequency-domain or time-domain. You are welcome to test this result using time series with defined spectral values. When analyzing "real-life" biological time series, however, the H value will change somewhat based on the length of the data, but this is a result of the long-range correlations of the time series, not an artifact of the analysis itself.

Before you begin:

The following assumptions have been made:

1. Horizon has been stored on your hard drive, and the relevant.dll's are in the same directory as the application. If one of the.dll's does not copy to your hard drive, you will get an error mes-

sage. This just means that you do not need that particular.dll. the program will work fine without it.
2. All files that are ready for analysis are saved as text files(*.txt)
3. These text files contain only numerical data
4. A text file called Htest.txt is also saved to the same directory in your hard drive

NOTE: Throughout this manual the various examples refer to the file called Htest.txt. This file was created to assist in learning how to use Horizon.

Starting Horizon

1. Execute the Horizon program
2. To import the data click:

a File
b Import Data
c Text File
d Select the file that has the data you wish to input.

3. Highlight the text file containing the data and click “Open.” This should create a continuous graph with event number (i.e., heartbeat number) on the x-axis and the magnitude of the signal of your imported data on the y-axis (for heartbeats, this might be milliseconds).

Preparation for Analysis

Once the initial graph appears on the screen, you will need to be set H parameters to give accurate output.

1. To prepare the data for analysis click:

a H Config
b H Parameters

2. In the box labeled “Hurst Parameters and Variables” click on the box labeled “M.” this will automatically set the maximum window size to the square root of the number of data points. We suggest that you use this setting for your data analysis.
3. To obtain accurate readings you must decide on the correct dimensional setting for those specific data.
4. To manipulate the dimensional setting click on the arrows to increase or decrease the dimensional value.
5. The best method in which to begin to analyze the data is to begin with a dimensional value of 1 and increase the value. At the same you should be noting the corresponding H for each respective dimensional setting.
6. Continue to increase dimensional setting by increments of one until the value of H does not change. This is the dimensional setting that should be used for analysis of your data.

Example1: Htest.txt

Dimension	H value
1	0.02
2	0.02
3	0.02
4	0.03
5	0.03
6	0.03
7	0.03
8	0.03
9	0.03
10	0.03

The H value reaches an asymptote at H = 0.03 and the smallest dimension at a dimensional value of 4. Thus, in the box labeled “D” you would enter 4. to avoid having to reanalyze large data sets, we usually choose a value which is higher by an additional 2 dimensions. This will not alter the value of H, but it avoids problems with heterogeneous data where the dimensional embedding may be underestimated if you look at only one set of data. Otherwise, you will have to pre-analyze all your data and then choose the highest dimensional value that results in an asymptotic value of H and then analyze your data using this value. We have found that time series where H values tend to be close to 0 require lower dimensional embedding constants than time series where H values are closer to 0.5.

Determining H using your parameters

Now that the proper dimensions have been determined you can use Horizon to manipulate the data.

1. Specification of Range

If you have a long data set and you only want to analyze a small part of it, Horizon allows the user to specify the range of the graphing window.

Click:

a File
b Extract Data
c Enter the minimum and maximum point values in the boxes provided

Horizon will create a new graph window with the user-specified minimum and maximum as the new beginning and end points.

Auto Tabs

This feature will determine an H value for a certain number of points. An example would be if you had a data set of 5000 points in length, you could set tabs to 1000 and the program would calculate the H value for each 1000 point interval (0-999, 999-1999, 1999-2999, 2999-3999, 3999-4999).

To use tabs click:

a H Config
b Auto-Tab
c Enter the number of points you want per segment
d "M" use best value
e "D" change the dimension to the same value that was determined for the entire data set

The values for the calculated Auto-Tabs are placed at the top of the graph. However, if you have a graph 10000 points in length, and you decide to do Auto-Tabs of 100, 100 H values will be placed at the top of the graph. The values will overlap rendering those calculated values unfit for reading. In this case click:

a H Config
b H Parameters
c H Tab at:

This feature allows the user to scroll down through the segments of the graph to determine the H values for each segment.

NOTE: Global is the H for the entire graph

Sliding Windows

This feature of Horizon will take the first n points (this is a value specified by the user) in a data set and will determine the H value for that segment. Then the segment will shift 1 and the program will calculate the H value for the same number of points but with a window shift of 1 unit.

Example 2: Htest.text

10000 point sample
Sliding Windows of 1000

To use sliding windows click:

a H Config
b Set Sliding Windows

c Width-size of the window specified by the user, in this example it is 1000
d Spacing-determines the value of the window shift. In other words, instead of finding the H value for the first 1000 points and then shifting over 1 unit, the program will find the H value for the first 1000 points, shift over 10 units and find the H value for the next 1000 points.
e M parameters-use best value
f D parameters-set the value for the same as global dimension value

NOTE: When you set sliding windows to large values, this can significantly increase computational load. The status bar at the bottom of the screen will inform you of progress.

Extracting Numerical Data With Sliding Windows

After the program has calculated the Sliding Windows for the graph the Horizon allows you to extract numerical values to allow the user to further analyze the data.

Click:
a H Config
b Extract H Data
c Text file

NOTE: After the text file for the output has been created, it may be easier to view the data using a spreadsheet.

The output will have this format:

X	Y	H	R	B
1000	1142.718	0.0472	-0.9997	-1.9528
1001	1065.112	0.0463	-0.9997	-1.9537
1002	1057.764	0.0445	-0.9997	-1.9555
1003	986.5709	0.0396	-0.9996	-1.9604
1004	925.0438	0.0409	-0.9996	-1.9591
1005	822.033	0.0369	-0.9996	-1.9631
1006	992.1111	0.032	-0.9996	-1.968
1007	1113.618	0.0336	-0.9996	-1.9664
1008	1022.453	0.0382	-0.9997	-1.9618

a x is the point number
b y is the value of the input.

c H value (since the slope is -D, H is simply 2-D).
d r is a measure of the sample correlation for the regression. Generally, if the time-series is fractal, the r-value should be close to -1.00
e b is the intercept for the regression (not very useful but the value is still reported).

Finishing Up

After all the data has been analyzed and you want to save the graph, Horizon will save the current dimensional, M settings, and Sliding Windows but will not save the Auto-Tabs.

Click:
a File
b Save As

Enter file name and save.

NOTE: Make sure the file has the file extension is.hor to go back to the data set, you can now use File “Open” to open the Horizon data file, rather than having to re-import your data and reset the parameters.

If you have any questions on using this program, please feel free to contact me at pbdp@helix.nih.gov. Ideally, you should have the application open on your machine when you call, as this will help us in answering your questions.