**Fractal Analysis of the Optimal Hydraulic Gradient Surface in Water Distribution Networks**

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# Reproducible results guide

## Designs

EPANET “.inp” data files of the corresponding optimal and non-optimal designs can be found in the folder “EPANET\_Designs”. These files can be processed by importing them in EPANET. In addition, the hydraulic simulation of each design was stored in a separate Excel spreadsheet and can be found in the “Excel\_Designs” folder.

## Cost curves and cost calculation

A python script for calculating the design costs and generating the corresponding cost curve is supplied inside the “CostCurves\_CostCalculation” folder in “Python\_Code”. The user should open the “CostCurve\_CostCalculation.py” file in any text editor or python integrated development environment and specify the required information. First, the user must type the file path to be opened. In this case, the corresponding Excel spreadsheet files are also included in the “CostCurves\_CostCalculation” folder. Then, the user must specify the diameter and unit cost units of measurement. When running the python script, a cost curve image and a text file are generated. The latter includes the cost of the optimal and non-optimal designs depending on the network and can be used to reproduce the information contained in Table S15-S17.

## Toro cost evolution figure

Fig. 6 can be reproduced by running the “Fig\_6.py” script inside the “CostCurves\_CostCalculation” folder in “Python\_Code”.

## R28, Cazucá, and New York Tunnels HGS figures

Fig. 8, 9 and 11 can be reproduced by running “Fig\_8.py”, “Fig\_9.py”, and “Fig\_11.py” scripts inside the “FractalAnalysis\_HGS” folder in “Python\_Code”.

## Fractal Analysis of the Hydraulic Gradient Surfaces

A python script for calculating the fractal dimension of the Hydraulic Gradient Surface is supplied inside the “FractalAnalysis\_HGS” folder in “Python\_Code”. The user should open the “FractalAnalysis\_HGS.py” file in any text editor or python integrated development environment and specify the required information. First, the user must type the file path to be opened. In this case, the corresponding Excel spreadsheet files were uploaded in the “Excel\_Designs” folder. Then, the user must specify the step size depending on the network to be analyzed. A list of the chosen step sizes is provided in the python script. It should be noted that the user must used the stipulated step sizes to obtain the same results as presented in the article. Once the user runs the script, a figure of the Hydraulic Gradient Surface will be generated, and the fractal analysis results will be printed in a separate text file. The latter includes the fractal dimension of the surface, the coefficient of determination, the log V(ε) and log ε data, which can be used to reproduce the information contained in Table 2 and 3.

## Fractal Analysis of the Hydraulic Gradient Surfaces Postprocessing

The “FractalAnalysis\_HGS\_Postprocessing.py” python script uploaded in the “FractalAnalysis\_HGS\_Postprocessing” folder in “Python\_Code”. The goal of the script is to generate the log V(ε) vs log ε figures as showcased in Fig. 10 and S14-S40. For this purpose, the user must open the script open in any text editor or python integrated development environment and specify the file path to the desired Excel spreadsheet. The corresponding Excel files were also uploaded in the same folder (“FractalAnalysis\_HGS\_Postprocessing”). If El Overo spreadsheet file is analyzed, then Fig. 10 will be reproduced.

## Fractal Analysis of the Network

The information in Tables 4-7 and S20-S22 can be reproduced by accessing the python scripts inside the “FractalAnalysis\_Network” folder in “Python\_Code”. As specified in the article, two scripts were written: one for networks with less than 250 nodes and the other for networks with 250 nodes or more. For the first case, the “FractalAnalysis\_Network\_1.py” script is suitable, while “FractalAnalysis\_Network\_2.py” is appropriate for the second case. The user should be aware that the proper script must be used depending on the network to obtain the same results as summarized in Tables 4-7 and S20-S22. The number of nodes of each network can be consulted in Table 1.

To run the scripts, the user must open them in any text editor or python integrated development environment and specify the file path to the desired Excel spreadsheet. In this case, the corresponding Excel spreadsheet files were uploaded in the “Excel\_Designs” folder. In addition, the user must specify the desired analysis criterion as established in the article. Once the user runs the script, a text file will be printed with the fractal dimension of the network and the coefficient of determination.

## Statistical postprocessing

Fig. 7 and 12 can be reproduced by running the “Fig\_7.py” and “Fig\_12.py” scripts inside the “Statistical\_Postprocessing” folder in “Python\_Code”. The mean and standard deviation of the diameter values of each design, as summarized in Table S18 and S19, can be calculated by running the “Mean\_StdDeviation\_Calculation.py” script stored in the same folder. Once again, the user must open the script in any text editor or python integrated development environment and specify the file path to the desired Excel spreadsheet. In this case, the corresponding Excel files are in the “Excel\_Designs” folder. The user should also be aware to correctly specify the units of measurement of the diameters as presented in the spreadsheet file. The script prints a text file containing the desired information.