Homework 3-extra

Fractals

(Max useful score: 100 - Available points: 120)

15-382: Collective Intelligence (Spring 2019)

Instructions

Homework Policy

Homework is due on Autolab by the posted deadline. As a general rule, you have a total of 6 late days. For this homework you cannot use more than 1 late day. No credit will be given for homework submitted after the late day. After your 6 late days have been used you will receive 20% off for each additional day late.

If you find a solution in any source other than the material provided, you must mention the source.

Submission

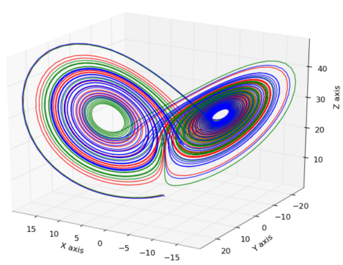
Create a zipped archive including: a PDF file with the answers to the provided questions (they can be handwritten, but in this case you must have / use a "readable" handwriting), files that have been used for dealing with the questions that require programming, a README file that specifies how to use / run the programming files. The zipped archive should be submitted to Homework 3-extra on Autolab.

Contents

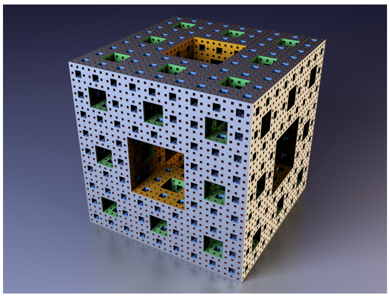
1 Measuring fractal dimension (100 points)

Read the attached paper *An introduction to dimension theory and fractal geometry: fractal dimensions and measures*. You only need to read up to section 5 (page 12). For the Koch curve mentioned at page 5 without further reference, you can find a simple yet complete description on the Wikipedia page https://en.wikipedia.org/wiki/Koch_snowflake.

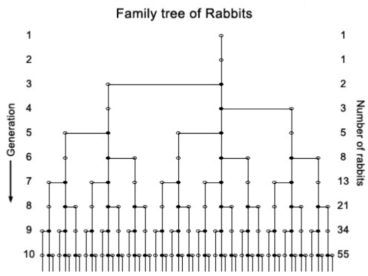
1. (50 points) Use the box-counting method to define an approximate measure of the fractal dimension of the Lorenz attractor that we have described in the classes. To generate the necessary data (for a given initial condition), you can use parts of the python code `viz-attractor.py` previously provided for the generation of orbits of chaotic systems. Note that you have to use different values of side length for the "boxes' , and have to consider the slope that fits the data in the log data representation. Report data and code.



2. (40 points) Generate the data to approximate a 3D Menger sponge, as described in https://en.wikipedia.org/wiki/Menger_sponge, and use the same approach as in the previous question to compute an approximation of the fractal dimension. Report data and code.



3. (20 points) The image below charts the development of a rabbit family tree, that grows according to the Fibonacci iterated map. Moving from top to bottom, each point represents a pair of rabbits (Empty dots represent immature rabbit pairs, while filled dots represent mature rabbit pairs capable of breeding). Why does this tree structure has the property of a fractal?



4. (10 points) Let's consider now the image of real tree (made of wood!), projected on a 2D plane. Does this tree representation has a fractal structure? Why?