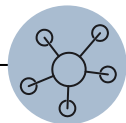


Flowers, networks and fractals:

a nature-inspired approach for
network analysis



Federica Trevisan

Supervisor: Giulio Rossetti

1

Natural Computing

2

Social Network Analysis

3

Fractal objects

1

Natural Computing

Recent and expanding **multidisciplinary** science.



Natural Computing

Nature-inspired computing

Evolutionary computing

Swarm Intelligence

Neurocomputing

Immunocomputing

Synthesis and simulation of natural phenomena

Fractals

L-Systems

Computation with natural materials

DNA computing

Quantum computing



Daucus

Carota

Umbel plant

It belongs to the Apiaceae family

Weed plant whose flower peduncles settle on the same level



Infestant Weed Optimization

Algorithm that mimics the behavior of weeds when they colonize and find a suitable place for growth and reproduction.

2

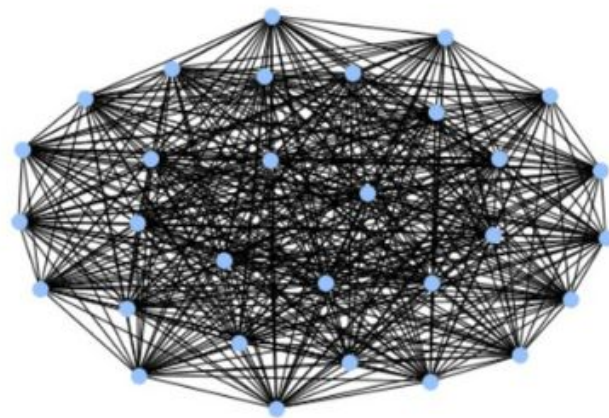
Social Network Analysis

Network study

Data structures composed of nodes and arcs



Picture of Daucus Carota



First iteration of DFNA

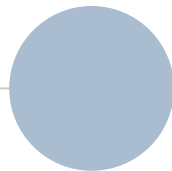


3

Fractal objects

Mathematical objects defined by Mandelbrot that have the property of self-similarity and a fractal dimension

Assumption: fractality of networks



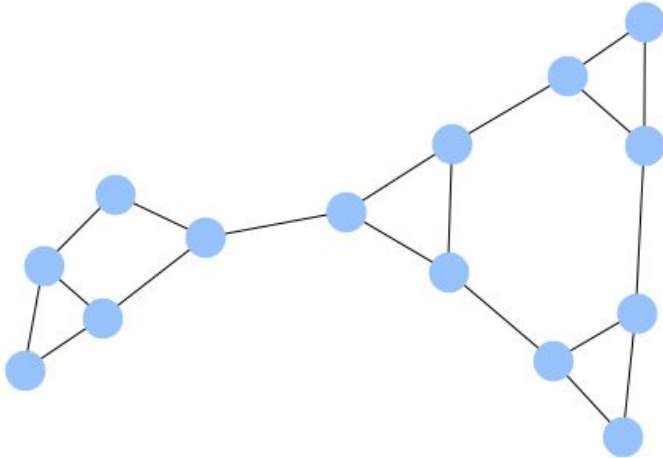
Proposed solution:

Daucus Fractal Network Analyzer

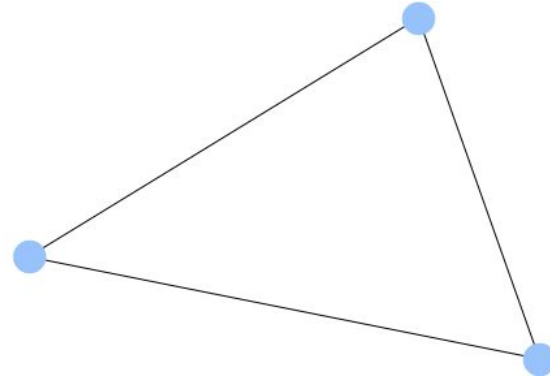
Python, NetworkX

Given a graph G
and a subgraph motif

Starting network G

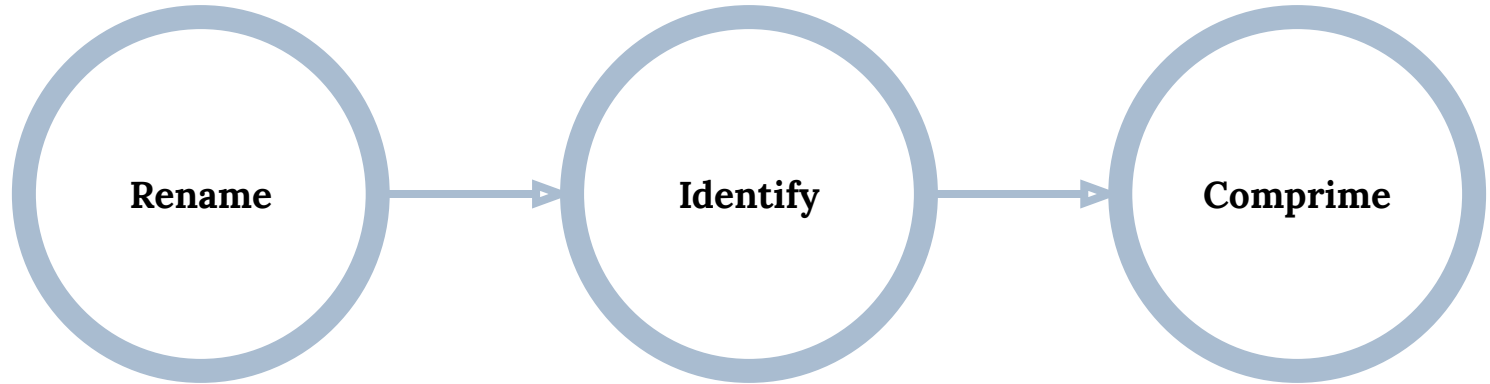


Motif

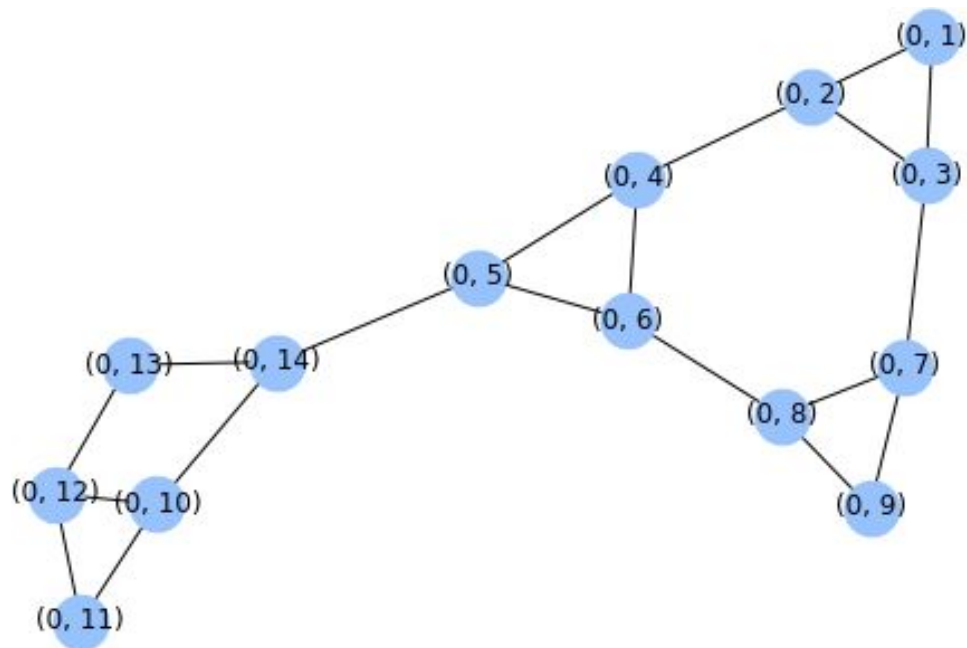




Daucus Fractal Network Analyzer



Rename



Node	Renamed node
1	$(0, 1)$
...	...
14	$(0, 14)$



Identify

Graph isomorphism problem

Determine if two graph have the same shape



Subgraph isomorphism

Determine if a subgraph belongs to a larger graph (NP complete)

Grandiso

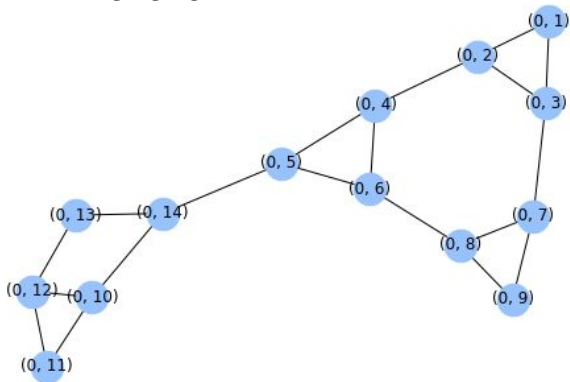
Motif extraction package



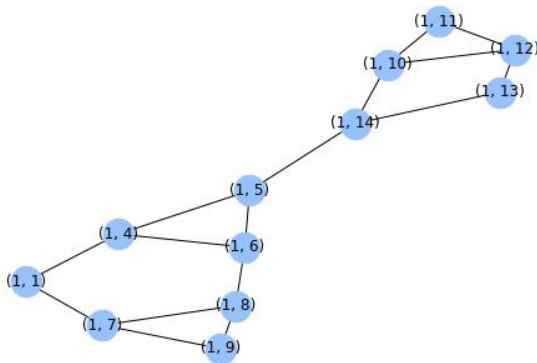
Three types of compression

- **Single**, compression of one motif at a time
- Mixed
- Fractal

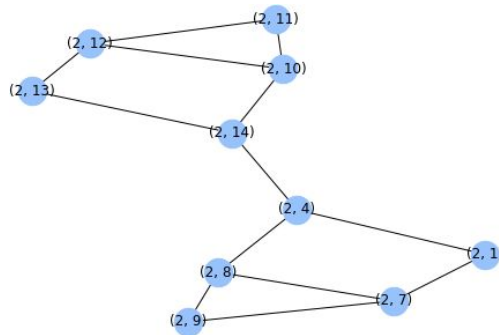
Level 0



Level 1



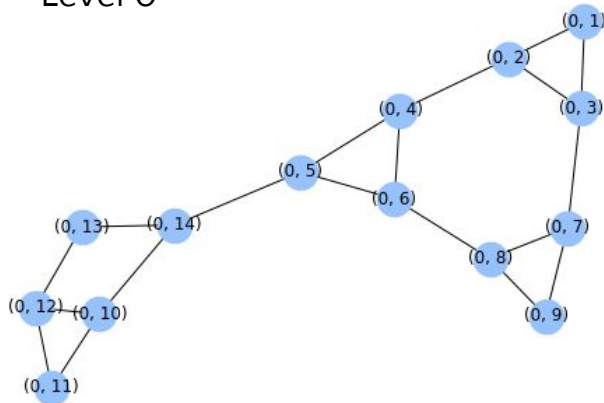
Level 2



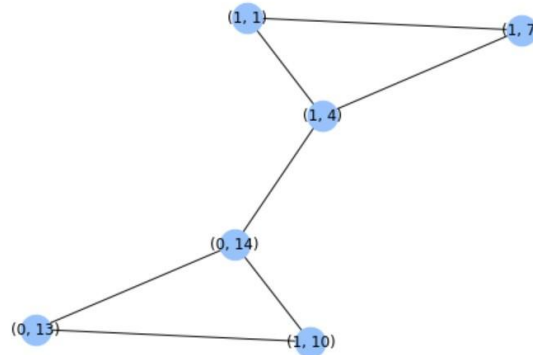
Three types of compression

- Single
- Mixed**, compression motif belonging to different levels
- Fractal

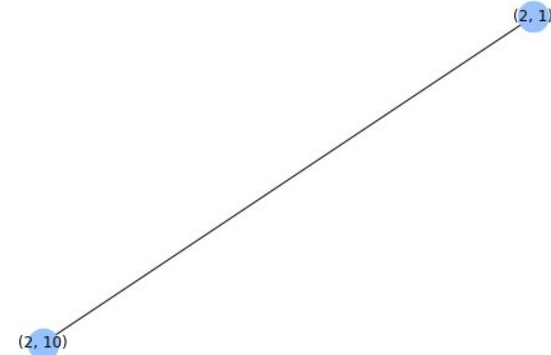
Level 0



Level 1



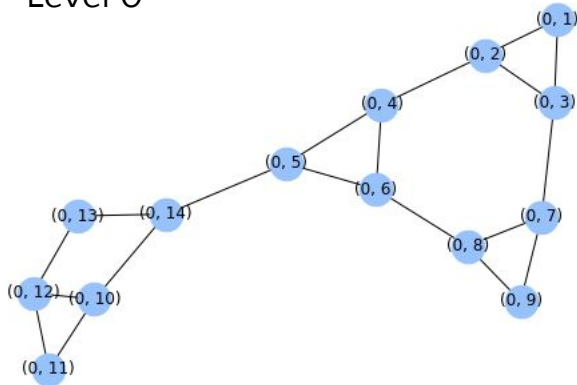
Level 2



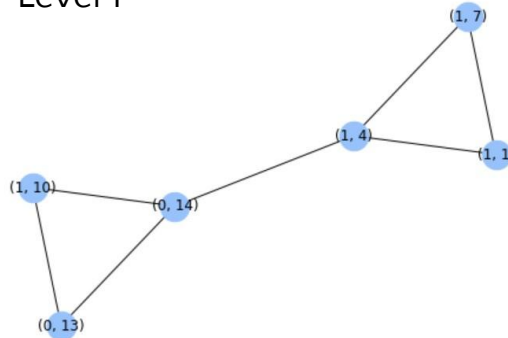
Three types of compression

- Single
- Mixed
- **Fractal**, compression of several motifs belonging to the same level

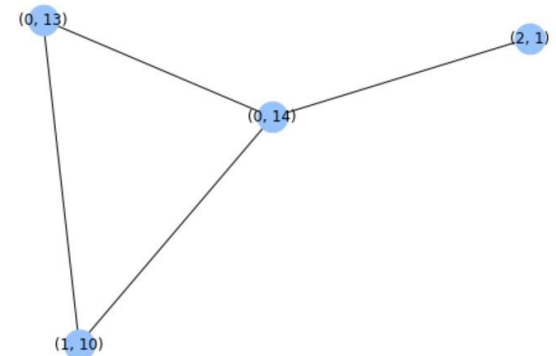
Level 0

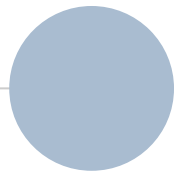


Level 1



Level 2





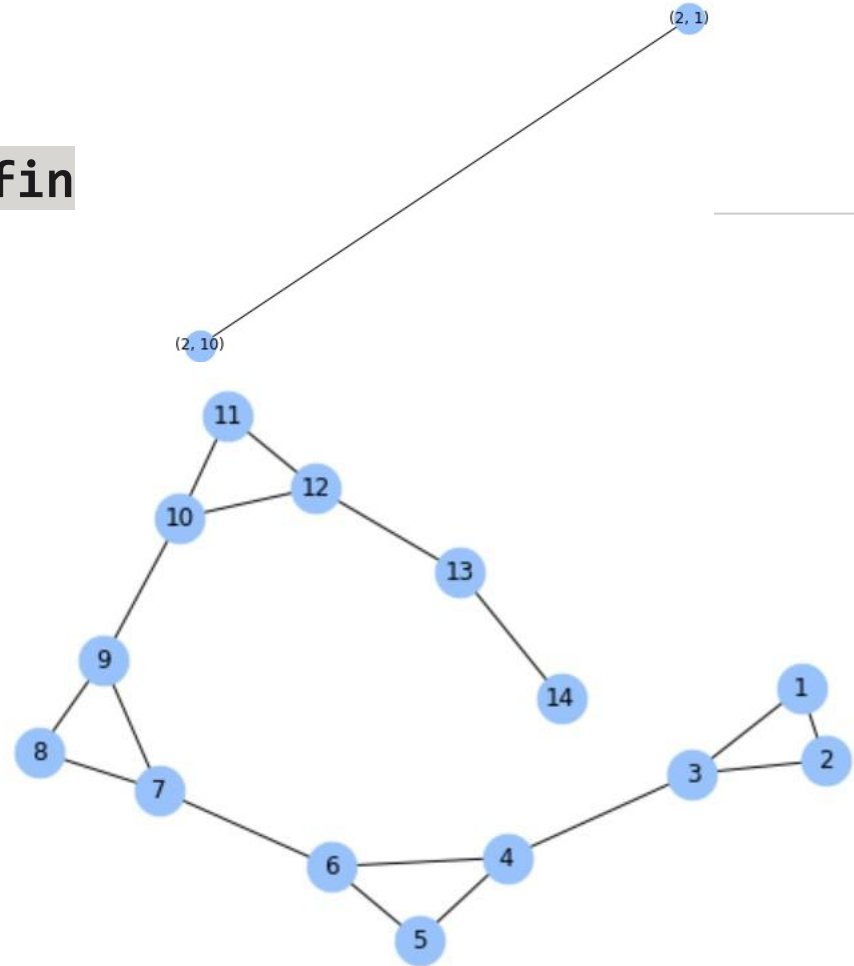
Reversed solution:

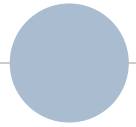
Daucus Fractal Network Analyzer Reversed

Given the final graph G_{fin} and a mapping table

$G_{final} = [(2, 1), (2, 10)]$

Node	Mapping
(1, 1)	[(0, 1), (0, 2), (0, 3)]
(1, 4)	[(0, 4), (0, 5), (0, 6)]
(1, 7)	[(0, 7), (0, 8), (0, 9)]
(1, 10)	[(0, 10), (0, 11), (0, 12)]
(2, 10)	[(1, 10), (0, 13), (0, 14)]
(2, 1)	[(1, 1), (1, 4), (1, 7)]





Experiments

Analyzes carried out on networks of various kinds



Experiments

Animal Social
Network

A Venn diagram consisting of four overlapping circles arranged horizontally. The first circle on the left is teal and contains the text 'Animal Social Network'. The other three circles are light gray and contain the text 'Brain Network', 'Ecology Network', and 'Chemical Network' respectively. The circles overlap in a way that creates various shades of gray in the intersection areas.

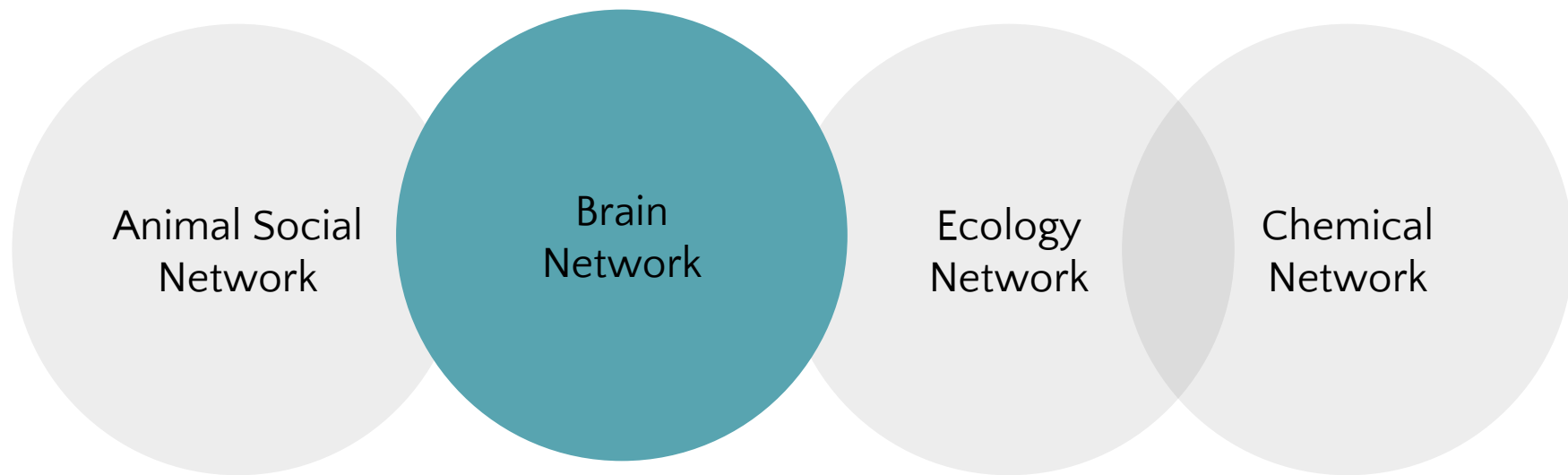
Brain
Network

Ecology
Network

Chemical
Network



Experiments





Experiments

Animal Social
Network

Brain
Network

Ecology
Network

Chemical
Network



Experiments

Animal Social
Network

The diagram consists of four overlapping circles arranged horizontally. The first three circles are light gray, and the fourth is a darker teal color. Each circle contains text. The circles overlap in a way that creates a continuous path from left to right.

Brain
Network

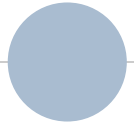
Ecology
Network

Chemical
Network



Results, levels and decrease of the nodes

Networks	Levels	Decrease
Animal	5	87%
Brain	4	60%
Ecology	7	98%
Chemical	20	26%



Conclusions

Procedure that leads to a 90% decrease in nodes in less than 10 levels

Chemical networks respond differently, they are less fractal



Future developments:

Botanical data

Using Computer Vision to have a database of umbellifers.

Rename with regex

Other node renaming and mapping memorization techniques for a more faithful reconstruction of the decompression to the starting one.

Further experiments

On larger networks and with other motifs with the aim of defining specific motifs recurring in certain groups of networks.



Future uses:

Network transfer

Interchange of networks containing sensitive data.

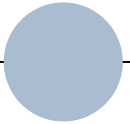
Network pruning

Definition of its state of fractality with consequent elimination of repetitive motifs because they can be defined as *noise*.

Other nature-inspired algorithms

Starting from DFNA, other algorithms inspired by natural phenomena can be developed.

Thank you.



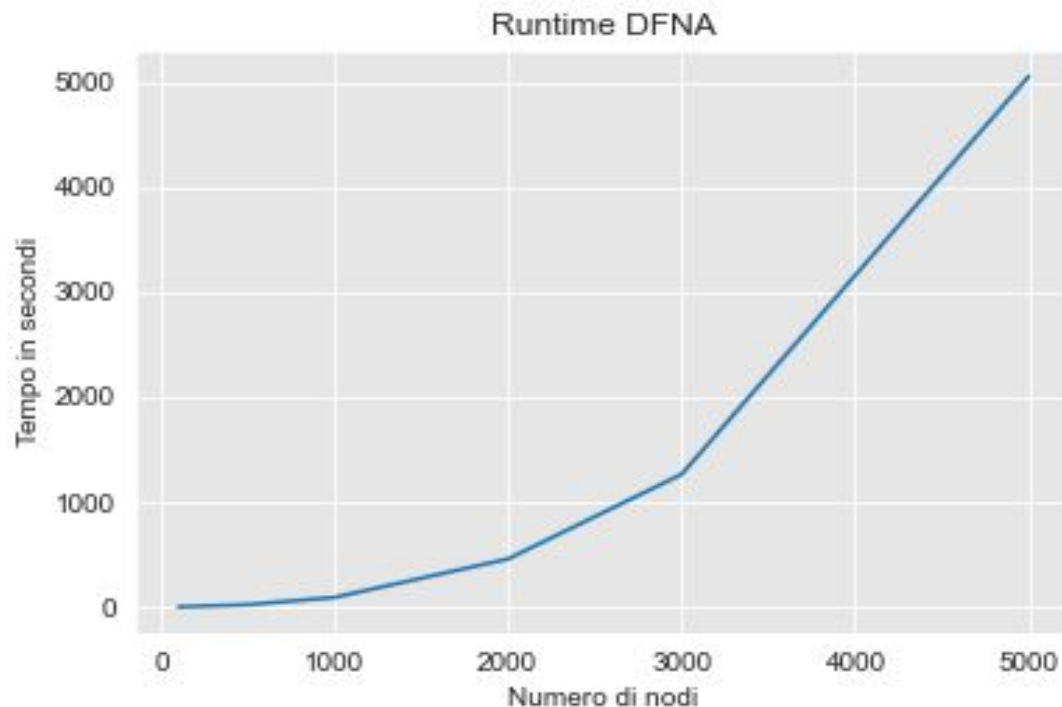


Additional resources:

- Repository Github:
https://github.com/kdd-lab/2020_Trevisan

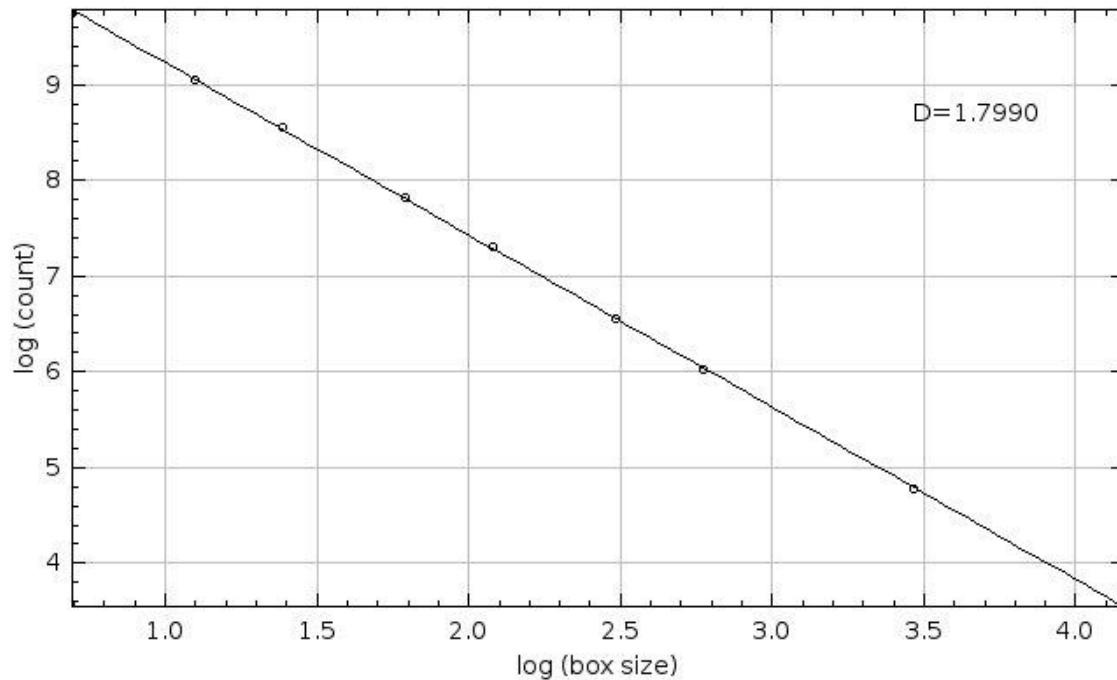


Calculation of execution time DFNA





Fractal dimension Daucus Carota



Genesis

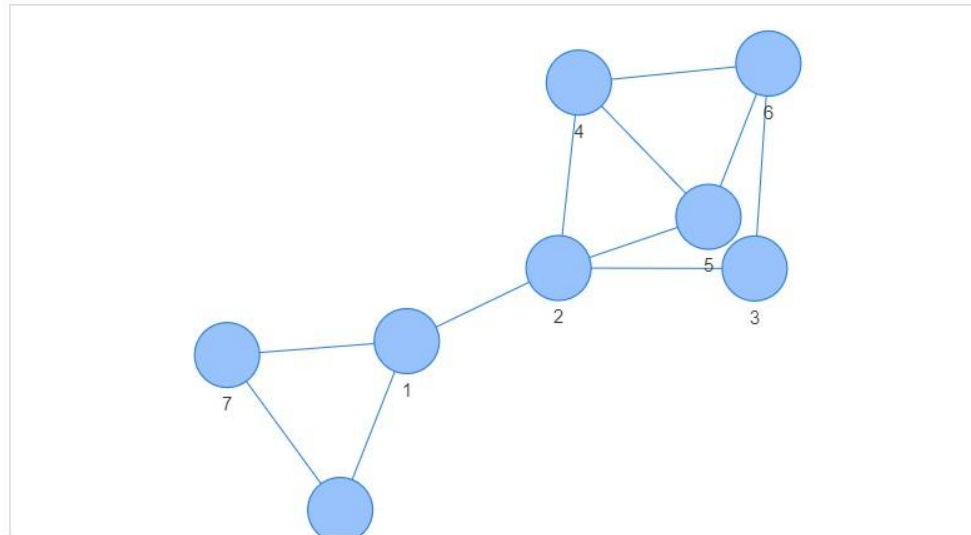


Daucus Fractal Network Analyzer

Federica Trevisan

Contributo algoritmico per semplificare il grafo trovando strutture ripetitive-ricorsive al suo interno.

Grafo:



Choose a compression method:

Selezionare tipo di compressione

Singola compressione

Dashboard

<https://share.streamlit.io/federikovi/tesi-dashboard/main/app.py>