FFR120, Simulation of Complex Systems
Homework 4

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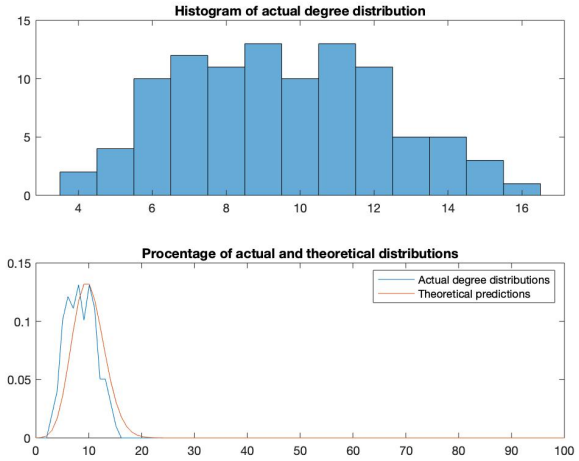
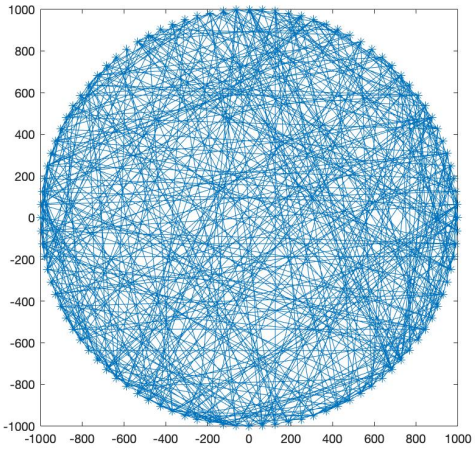
1 Exercise 1



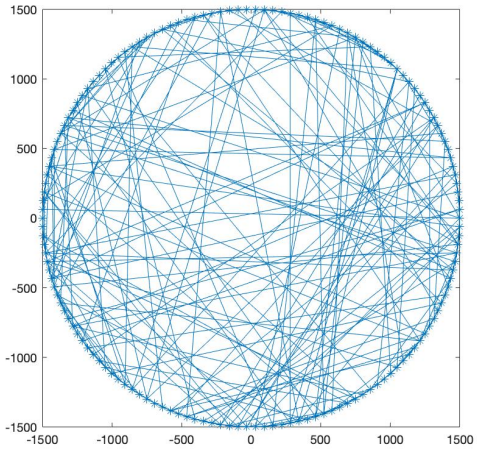
(a) Histogram plot of the actual degree distribution on the top and degree distribution plot of the actual distribution and theoretical prediction below.



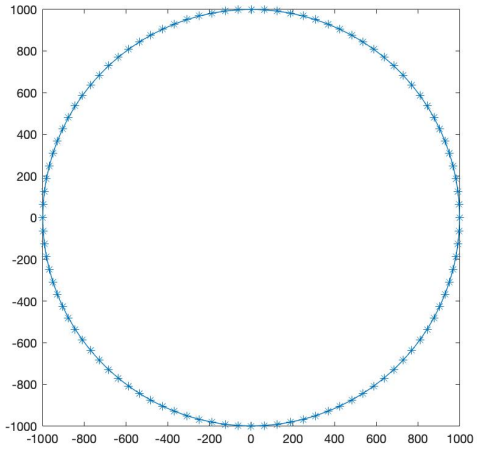
(b) A visualisation of the network (a graph plot) with the size of the network chosen to 100 and probability chosen to 0.1

Figure 1

2 Exercise 2



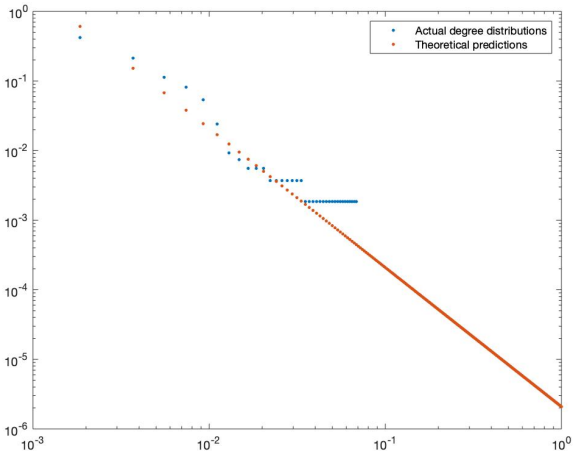
(a) A small world network with shortcuts and size of network set to 100, probability set to 0.4 and c chosen to 6.



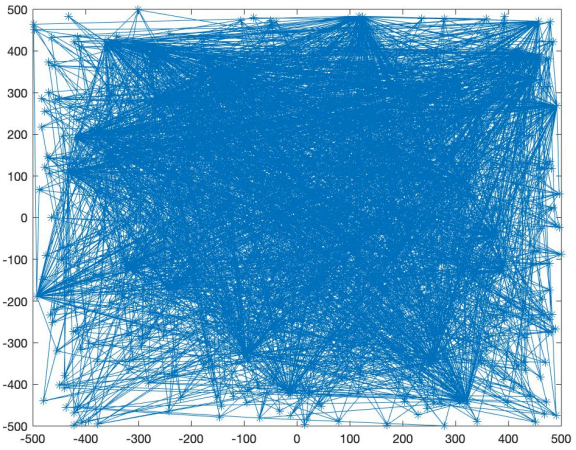
(b) A small world network without shortcuts and size of network set to 100, probability set to 0.4 and c chosen to 6.

Figure 2

3 Exercise 3



(a) The power law (loglog) plot with the probabilities on the x-axis and the degrees on the y-axis.



(b) A visualisation of the preferential growth model network with number of nodes = 40, size of network = 1000, probability=0.4, parameter m=4 and added nodes=500.

Figure 3

4 Exercise 4

The clustering coefficient is found to be 0.611279563371740

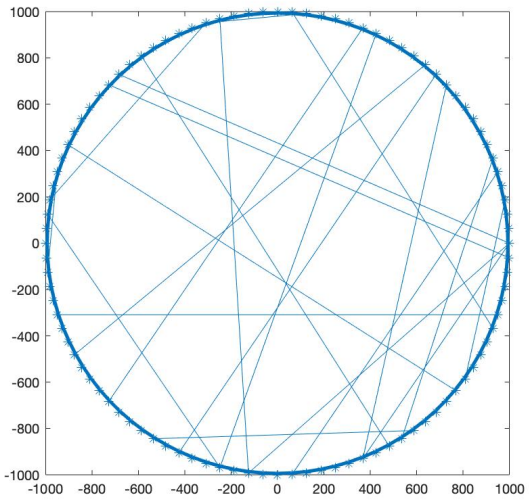


Figure 4: A graph plot of the example small world network with clustering coefficient 0.611279563371740.

5 Exercise 5

The element (i,j) gives the number of (directed or undirected) walks of length n from vertex i to vertex j. If n is the smallest nonnegative integer, such that for some i, j, the element (i, j) of A^n is positive, then n is the distance between vertex i and vertex j, which is how on can find the length between node i and j.

The average length is 2.932323232323232 and the diameter is found to be 5 length units.

6 Exercise 6

6.1 Network 1

Network 1 should probably be the Western States power grid where the nodes represents various transmission substations and the edges represents the power transmission lines. Generators are likely to connect to many other nodes, which is why high degree nodes may be generator nodes. The edges connect transmission substations to distributions substations and are therefor most likely to be centered around 2 or 3. Thereby the average path length and diameter has a large value. Distribution substation are also likely to have a low degree. This can be seen in the distribution figure [5].

- Clustering coefficients for = 0.103153224528601
- Average length = 18.989185424445751
- Diameter = 47

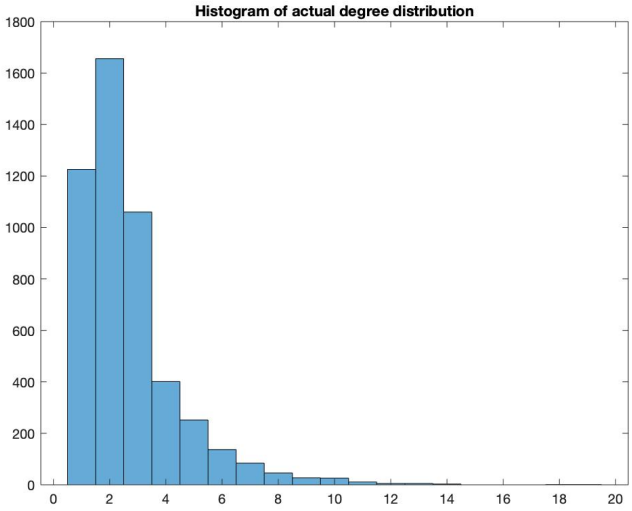


Figure 5: Histogram plot of the degree distribution for network 1

6.2 Network 2

Network 2 is most likely a small-world network since small-world networks tend to contain sub-networks which have connections between almost any two nodes within them, which follows from the defining property of a high clustering coefficient and thereby short average path length due to the many edges. Network 2 should thereby be the social network.
The degree of a node is the number of connections it has. From figure [6], it is clear that network 2 follows a power law degree distribution, which also is the distribution for a social network.

- Clustering coefficients for = 0.166269083969466
- Average length = 3.606032017315423
- Diameter = 8

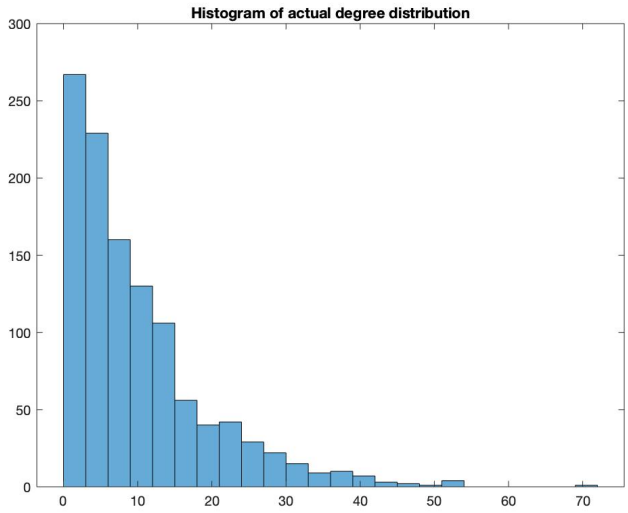


Figure 6: Histogram plot of the degree distribution for network 2

6.3 Network 3

Network 3 has a large average length and diameter as well as the lowest clustering coefficient of the three network that was observed. This result indicates few connection/edges between each pair of nodes. These properties fits best in the protein network with yeast protein interaction best, since interactions with proteins are rather specific than random. The majority of the degrees are low since there are few connections to each node due to the functionality of the protein interactions.

- Clustering coefficients for = 0.079369651086241
- Average length = 6.812366015065626
- Diameter = 19

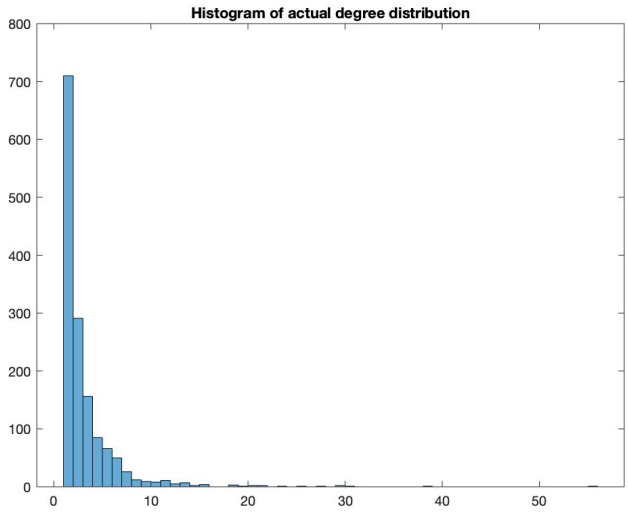


Figure 7: Histogram plot of the degree distribution for network 3