Complex and Social Networks

Laboratory Project 1

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All the code can be found on Github here.

1 Plot A

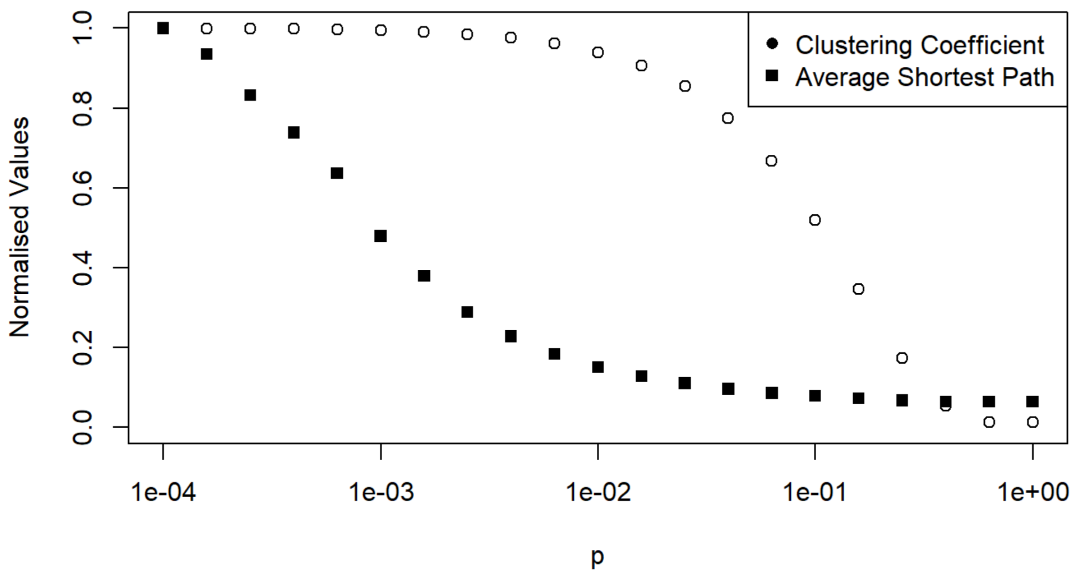

Figure 1: Clustering coefficient and average shortest path as a function of the parameter p of the WS model

To generate Plot A, we simulated the Watts-Strogatz (WS) small-world model for different rewiring probabilities p (from 0 to 1). For each p, the mean of 100 runs was calculated for the clustering coefficient and average shortest-path length. The values were normalised by the value obtained from the leftmost point, when $p = 0$, and both metrics were plotted on the same axes to visualise how the network evolves from a regular graph to a random graph as p increases.

The clustering coefficient stays high at low and intermediate p values (up to 1e-03), meaning the graph keeps strong local connections even with some randomness. As p approaches 1, the clustering coefficient drops sharply which reveals the breakdown of local structures when the graph becomes fully random.

The average shortest-path length shows a fast decline as soon as p increases slightly. Even with minimal rewiring, the network becomes much more globally connected and drastically reduces the distance between nodes. As p approaches 1, the path length stabilises at a low level.

In conclusion, the WS model highlights the balance between clustering and path length. For small values of p, the network retains high local clustering but significantly shorter paths. Here we capture the essence of small-world networks found in many real systems.

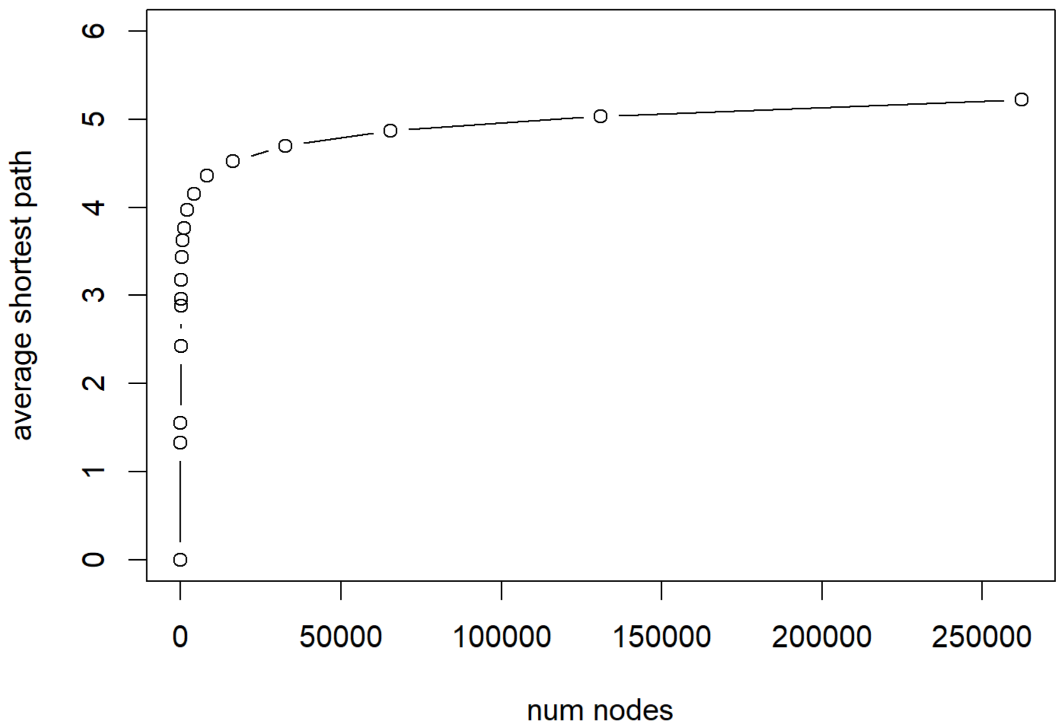

Figure 2: Length of average shortest path as a function of network size in ER model.

2 Plot B

Plot B was generated by simulating Erdős-Rényi (RE) model for different number of nodes (n) and computing the average shortest path. We used $n = 2^k$, where k is an integer in range 1 to 18. For each n, the simulation was repeated twice, and the average value of shortest path was calculated. Parameter p signifies probability of each edge being created. It was determined dynamically based on n, using the following equation: $p = \frac{1.0000001 * ln(n)}{n}$. The plot visualized the speed of average shortest path increase, compared to the number of nodes.

It can be observed, that the average shortest path grows relatively quickly for low values of n and starts to slow down, as n increases. The decreasing value of p seems not to affect the speed at which the average shortest path grows, despite creating more and more sparse networks.

Based on the graph, we can conclude that the relationship between the number of nodes and the shortest path is logarithmic. It can also be noticed, that the relationship does not seem to be affected by the changing value of p.