Network Science
Rubric Assignment 3

Code for the following tasks. All results must be submitted using a well-documented Jupyter Notebook.
Please submit a zip folder containing the data, Jupyter Notebook, and the PNGs of the graph where required. Use the filename convention: GroupNo.1_Assignment1.

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1. Consider a real-world graph of at least 1000 nodes. Implement the (a) Configuration Model as well as the (b) Edge-Swapping strategy for generating a random graph to preserve the degree sequence of a real-world graph. Plot the original degree distribution as well as that generated through these strategies (averaged over 100 instances). [10 marks]

Submit a Jupyter Notebook named as **Q1** and implement both parts (a) and (b) as instructed. Consider a weighted and directed real-world network of at least 1000 nodes.

(a) Configuration Model for Random Graph Generation
- Correct implementation preserving degree sequence. (2 marks)
- Comparison plot of the real-world graph with the averaged random graph (100 instances). (2 marks)
- Proper x and y-axis labeling, discussion of findings, save plot in PNG format. (1 mark)

(b) Edge-Swapping Strategy
- Correct implementation of Edge-Swapping strategy for generating a random graph. (2 marks)
- Comparison plot of the real-world graph with the averaged random graph (100 instances). (2 marks)
- Proper x and y-axis labeling, discussion of findings, save plot in PNG format. (1 mark)

2. Plot the degree correlations of the real-world network using knn vs k plot. Compare the degree correlations with that of the corresponding random graph (averaged over 100 instances). [5 marks]

Submit a Jupyter Notebook named as **Q2.**
- Compute KNN vs k for the real-world network. (1.5 marks)
- Averaged KNN vs k for random graphs (100 instances). (1.5 marks)
- Create a comparison plot of degree correlations of real-world network and averaged random graph. Proper x and y-axis labeling. Save the image as PNG. (2 marks)

3. Write a strategy to generate all possible unique ‘three node connected subgraphs’ in a directed graphs. For a real-world directed network of your choice, compute the Z-score for each

of these vis-à-vis its random counterpart. State which of the subgraphs may be considered as motifs/anti-motifs. [5+5+5 marks]

Submit a Jupyter Notebook named as **Q3.**

(a) Strategy to Generate All Unique 3-Node Connected Subgraphs (Directed). (5 marks)

- Identification and classification of unique subgraphs. (2 marks)
- Efficient strategy implementation. (3 marks)

(b) Compute Z-Score for Each Subgraph. (5 marks)

- Randomization method used for comparison. (2 marks)
- Correct calculation and interpretation of Z-score. (3 marks)

(c) Identify Motifs and Anti-Motifs. (5 marks)

- Classification based on Z-score threshold. (2 marks)
- Biological/structural interpretation and insights. (3 marks)