International Institute of Information Technology, Hyderabad

SC1.440: Dynamical Processes in Complex Networks

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Instructions

You are required to choose one of the three real-world networks provided below and answer the following questions. Submit your solution as a report containing your code, results, visualizations, and brief interpretations. Interpretations should reflect your understanding. Marks will be based on what you submit, so be sure to include everything you want evaluated. Afterwards, no claim to make changes based on assumptions will be entertained.

Questions

1a.

Briefly define all the following centrality measures. Compute centrality scores for all vertices and edges in your chosen network:

1. Edge betweenness centrality
2. Edge strength
3. Vertex betweenness centrality
4. Vertex closeness centrality
5. Vertex strength
6. Vertex eigenvector centrality

1b.

Next, gradually remove vertices with the highest centrality values one by one until the network becomes fragmented into exactly two connected subcomponents. Ignore the removed vertex(s) when analyzing the resulting subcomponents. Report your findings and interpretations for all centrality metrics.

$[\mathbf{3+3=6}]$

2.

Define an Eulerian trail and an Eulerian circuit. For each of the three given graphs, determine whether it contains an Eulerian trail or an Eulerian circuit. If it does not, specify the modifications needed to transform the graph so that it possesses an Eulerian trail or circuit.

$[\mathbf{0.5+2+1.5=4}]$

Available Networks

1. **Zachary karate club**
   File: `out.ucidata-zachary`
   Inside file: edge list
   Network: binary, symmetric
   The karate club network was constructed by Wayne Zachary and consists of 34 vertices and 78 edges. An edge exists if two individuals were consistently observed interacting outside normal club activities over three years. Vertex 1 represents the instructor (Mr Hi) and vertex 34 the president/administrator (Mr John A.), with all other vertices representing club members. The network layout clearly shows two groups — roughly half the vertices in a group with vertex 1 and the rest with vertex 34.

2. **Human epileptic brain**
   File: `mtl-183-30.xlsx`
   Inside file: correlation matrix
   Network: weighted, symmetric
   Functional brain network derived from invasive EEG recordings of an epileptic patient with seizure onset at TL electrodes. Vertices correspond to iEEG channels, and edges represent correlation-based functional connectivity weighted by interaction strength. Please reach out for more info.

3. **Californian sparrow flock**
   File: `aves-2010.edges`
   Inside file: edge list
   Network: weighted, symmetric
   Social interaction networks of *Zonotrichia atricapilla* (golden-crowned sparrows) in California, USA. Vertices are individual birds, and edges represent group co-membership, weighted by the simple ratio association index. A flock is defined as birds within approximately 5 m of each other, with data collected through survey scans over three months using focal follow methods.

Submission Guidelines

1. Submit your work as a Jupyter Notebook with all code cells executed. Ensure that each section of the code is clearly explained using Markdown, specifying what each part does. You may use built-in functions, but if the chosen network is not handled properly by them, write your own implementation. Verify the results thoroughly from all possible perspectives to confirm that everything is handled correctly.
2. Visualizations must include all the necessary ancillaries.
3. Interpretation should reflect your understanding of what you've done.

Note: Make sure to normalize centrality measures appropriately and handle disconnected components if present in your chosen network.