

Community Detection: Assignment 2

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Q1: Spectral Decomposition - Single Iteration

In this section, we perform one iteration of the Spectral Decomposition technique and visualize the results.

Implementation Summary

First, i construct the adjacency matrix using the provided node connection list. Then, i calculate the degree matrix from the adjacency matrix. Next, i perform eigen decomposition to obtain the Laplacian matrix (L) and extract the Fiedler vector by selecting the vector corresponding to the first non-zero eigenvalue. Finally, i use the indices where the values of the Fiedler vector are positive to partition the nodes.

Results

i present the sorted Fiedler vector, associated adjacency matrix, and the graph partition for both the Facebook and Bitcoin datasets.

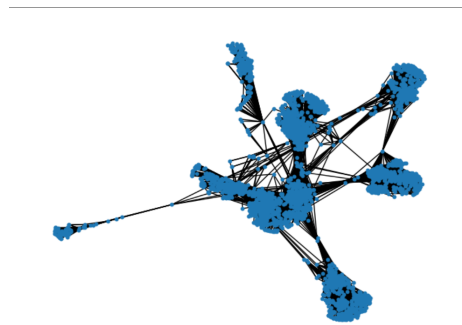
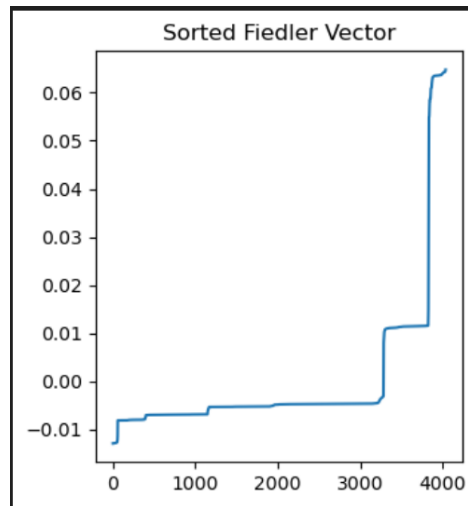
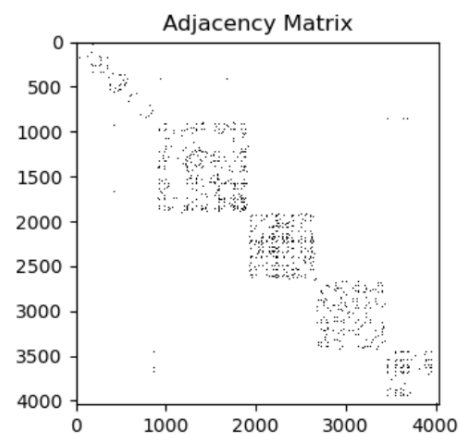


Figure 1: facebook original graph



(a) Sorted Fiedler Vector for Facebook dataset

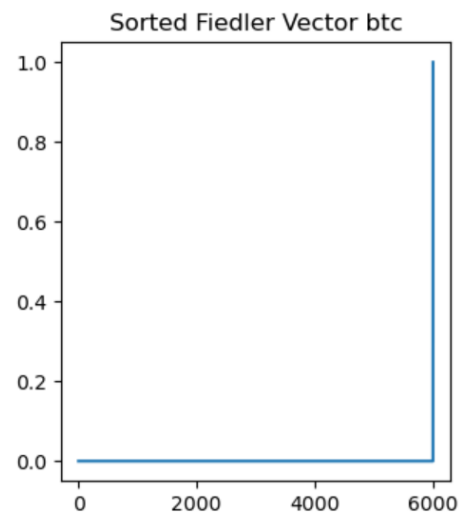


(b) Associated adjacency matrix for Facebook dataset

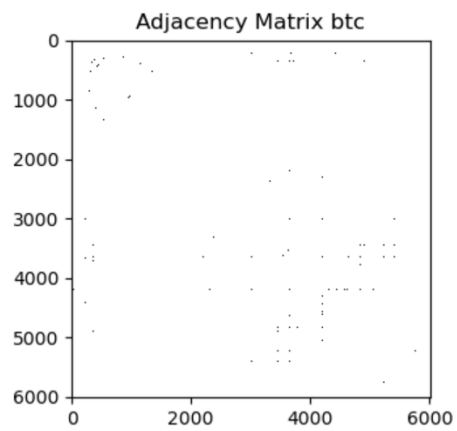


(c) Facebook Graph Partition

Figure 2: Three Figures in One Subgraph for Facebook Dataset



(a) Sorted Fiedler Vector for Bitcoin dataset



(b) Associated adjacency matrix for Bitcoin dataset



(c) Bitcoin Graph Partition

Figure 3: Three Figures in One Subgraph for Bitcoin

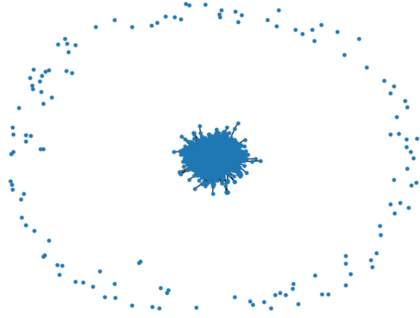


Figure 4: bitcoin original graph

Q2: Automated Algorithm for Community Detection

I propose an automated algorithm to determine the right set of communities using the spectral decomposition method. My stopping criterion is based on conductance values.

Algorithm Implementation

1. Threshold the Fiedler vector at 0 to obtain two partitions, one with values above 0 and one with values below 0.
2. Calculate the conductance value for each partitioned graph.
3. If the conductance value is above a predefined threshold, continue partitioning recursively.
4. Stop when the conductance value falls below the threshold.

Q3: Adjacency Matrix Sorted by Fiedler Vectors

plot the associated adjacency matrix sorted by Fiedler vectors for subgraph partitions and visualize the obtained graph.

Results

We identified a total of 7 communities after running the Spectral Decomposition algorithm.

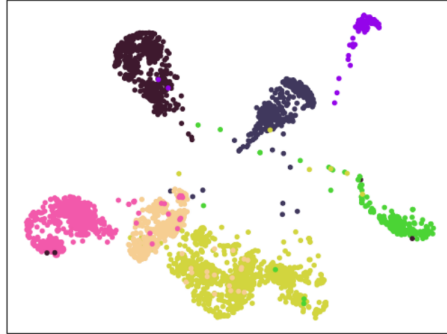


Figure 5: Plot of associated graph matrix sorted based on Fiedler vector of subgraph partitions

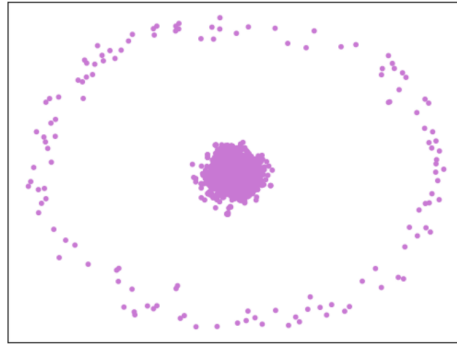


Figure 6: Plot of associated graph matrix sorted based on Fiedler vector of subgraph partitions

Q4: Louvain Algorithm - One Iteration

we apply the Louvain algorithm and show the communities obtained after one iteration.

Implementation Summary

The Louvain algorithm updates node communities to maximize modularity. It maintains dictionaries for node-to-community mapping and degree values for communities.

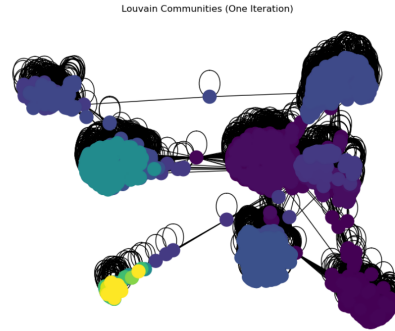


Figure 7: Graph Visualization after 1 iteration on Facebook dataset using Louvain algorithm

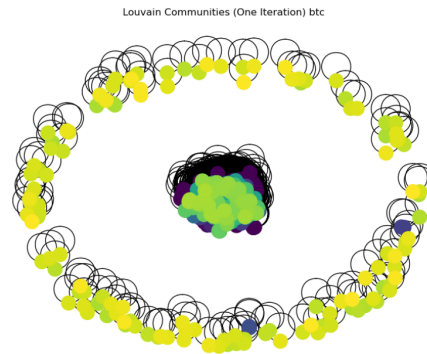


Figure 8: Graph Visualization after 1 iteration on Bitcoin dataset using Louvain algorithm

Q5: Selecting the Best Community Decomposition

To pick the best decomposition of nodes into communities, i compute the mean conductance value for each composition. The composition with the highest mean conductance is considered the best.

Q6: Running Time Comparison

We compared the running times of the Spectral Decomposition and Louvain algorithms for one iteration on the provided datasets.

* The Louvain algorithm was implemented with parallel processing, reducing the running time. These times are subject to the threshold set for stopping

Algorithm	Facebook Dataset	Bitcoin Dataset
Spectral Decomposition	2 min	4 min
Louvain	7 min*	8 min*

criteria.

Q7: Algorithm Comparison and Conclusion

In my opinion, the Louvain algorithm generally produces better communities due to its exhaustive search over all possible combinations of community partitions. However, it is slower compared to Spectral Decomposition.