

Data Structures and Algorithms in Python

Project 5 – Graph Theory Applications and Algorithms

This project is designed to deepen your understanding of graph algorithms by applying them to real-world data. You will design a project that uses graph theory to address a question or problem that you are interested in. Examples of project steps and tutorial code are in the text that follows.

Project Framework

Task 1: Domain Selection - Choose a domain of interest such as logistics, urban planning, biological systems, gaming, literature, or any other field where graph theory is applicable.

Task 2: Problem Identification - Identify a specific problem or question within the chosen domain that can be addressed with graph theory. This might involve routing problems, network optimization, analysis of interactions, etc.

Task 3: Research - Conduct preliminary research to understand the problem context and how graph theory has been or can be applied.

Task 4: Data Collection/Generation - Gather or simulate data needed for the project. This could be real-world data from public datasets or APIs, or synthetic data created based on realistic assumptions.

Task 5: Graph Construction and Analysis - Build a graph model of the problem, apply graph algorithms to analyze the data, and derive insights or solutions. Algorithms might include shortest paths, maximum flows, centrality measures, clustering, etc.

Task 6: Visualization and Interpretation - Visualize the graph and any results of the analysis using Python libraries. Interpret the outcomes in the context of the chosen domain.

Deliverables

Report/Presentation: A detailed description of the domain, the problem addressed, the graph model used, the analysis performed, and the findings or recommendations. Include visualizations and code snippets.

Code: Your complete Python code used for building the graph, performing analysis, and generating visualizations.

You may combine these two components by completing the project in a Jupyter notebook.

Resources

You should conduct significant research both in your domain of interest, and on NetworkX and Graph algorithms that may be applicable to your project. Some useful resources are listed below, but you are strongly advised to find your own resources in addition to these.

- NetworkX documentation: <https://networkx.org/documentation/stable/reference/index.html>
- Stanford Large Network Dataset Collection: <https://snap.stanford.edu/data/index.html>
- AI coding assistance from Codium, ChatGPT, Gemini, etc.

Example 1: City Accessibility and Network Resilience Analysis Using OSMnx

Use OSMnx to analyze and improve the resilience and accessibility of urban infrastructure networks in a chosen city. Simulate scenarios such as road closures or infrastructure failures and propose improvements or emergency responses.

Background Research and Data Collection

- Choose a city and research its major transportation issues or past infrastructure challenges.
- Use OSMnx to download and visualize the city's street network.
- Understand how street networks can be modeled as graphs and how various graph properties can reflect real-world traffic conditions.

Simulation and Improvement Proposal

- Simulate disruptions in the network, such as closing major streets or intersections, and analyze the impact on network accessibility and connectivity.
- Apply graph theory algorithms to identify critical nodes and edges, simulate disruptions, and propose alternative routes or network enhancements.
- Learn to apply algorithms like shortest path, network flow, and centrality measures to real-world problems.

[Code tutorial related to this example](#)

https://sustainability-gis.readthedocs.io/en/latest/lessons/L2/spatial_network_analysis.html

Example 2: Creating a Social Network Analysis Tool

Create a Python tool that can import, visualize, and analyze social networks from real data (e.g., social media APIs or simulated datasets). Explore concepts such as network influence, community detection, and information spread.

Tool Development and Data Import

- Develop a tool that can construct social networks from datasets. Optionally, you could use APIs from platforms like Twitter or Reddit to fetch real social network data.
- Use NetworkX to manage and analyze the network, and Matplotlib or Plotly for visualization.
- Understand data structures suitable for social network analysis and how to manipulate and visualize these structures using Python.

Analysis and Application

- Analyze the social network to find key influencers, community structures, or simulate how information (or misinformation) spreads.
- Implement algorithms for centrality measures, community detection, and percolation theory.
- Apply complex graph algorithms to analyze social structures and behaviors.

[Code tutorial related to this example](#)

https://networkx.org/nx-guides/content/exploratory_notebooks/facebook_notebook.html