Stock Market Tangle

Group Name: Queue-ties

Group Members: Avani Sood, Guntesh Singh, Khushi Dhingra, Saanvi Jain, Vaibhavi Kolipaka

Introduction

In this project, we present "Stock Market Tangle," a graph-theoretic approach to modeling a financial market as a network, where stocks are interconnected through price correlations and characterized by market traits such as volatility and stability. We adopt a financial theme to explore market dynamics, simulating disruptions such as volatility-driven connection losses that mirror economic shocks. This framework reimagines the market as a dynamic system akin to a social network, enabling the analysis of structural patterns like diversified market segments, influential stocks, and industry clusters, while facilitating portfolio optimization through recommendations.

Using graph theory, we aim to analyze the network to uncover cohesive segments, identify high-impact assets, detect sector groupings, and propose investment strategies. By incorporating trait-driven interactions and volatility-induced "breakups," the study simulates realistic market behaviors across varied economic scenarios, such as bull and bear cycles. Results will be evaluated using metrics like network cohesion, centrality stability, and recommendation accuracy, with visualizations including interactive network layouts and animated market fluctuations.

Algorithms

We aim to analyse and compare seven algorithms to address connected components, traversal, centrality, community detection, and recommendations.

1. Union-Find: A data structure algorithm that efficiently merges nodes into disjoint sets and checks their connectivity. It identifies market segments (groups of correlated stocks) by merging stocks based on correlation strength, using path compression and union-by-rank for near-linear time complexity.

2. Breadth-First Search (BFS): A traversal algorithm that explores the graph level by level from a starting node, computing shortest paths in unweighted graphs. It maps investment paths by finding correlation chains, prioritizing low-volatility routes for diversification.

3. PageRank: An iterative algorithm that ranks nodes based on their connectivity, modeling influence through a random walk with damping. It identifies dominant stocks whose price movements influence the broader market, weighted by correlation strengths.

4. Depth-First Search (DFS): A traversal algorithm that explores deep correlation paths before backtracking. In this project, DFS uncovers tightly linked stock clusters and hidden dependencies, helping detect isolated or high-risk stocks during market disruptions.

5. Girvan–Newman Algorithm: A community detection method that removes high-betweenness edges to reveal clusters. We use it to identify sector-based stock groups and key "bridge" stocks linking industries, offering insights for diversification and risk analysis.

6. Louvain Algorithm

A modularity-based community detection method that groups nodes to maximize the density of connections within clusters. We use it to identify strongly connected stock communities or "market tribes," where members share high correlation and similar traits. By adjusting edge weights using tag similarity, Louvain helps us capture how sectors form, split, or merge during market fluctuations.

7. Node2Vec for Embedding-Based Recommender

A graph embedding algorithm that learns vector representations of nodes using biased random walks. It captures both local and global relationships, allowing for similarity-based analysis. We use Node2Vec to generate embeddings of stocks to find structurally or behaviorally similar assets, enabling portfolio recommendations. Dynamic walk adjustments shall be used to simulate market cycles, reflecting how relationships between stocks shift under volatility.

Algorithm Comparison

To evaluate the seven algorithms — Union-Find, Breadth-First Search (BFS), Depth-First Search (DFS), PageRank, Girvan–Newman, Louvain, and Node2Vec — we will compare their performance across structural, computational, and financial aspects. This will help identify which approaches are best suited for analyzing market connectivity, influence, and community behavior.

Each algorithm serves a distinct purpose: Union-Find identifies connected market segments, BFS and DFS explore traversal patterns, PageRank highlights influential assets, Girvan–Newman and Louvain detect community structure, and Node2Vec generates embeddings for portfolio recommendations. Together, they provide a complete view of the market network.

The comparison will focus on three key dimensions:

- *Efficiency*: Measuring runtime, scalability, and memory use across networks of varying sizes and densities.
- *Accuracy and Structure*: Evaluating modularity (for community algorithms), path metrics (for BFS/DFS), and rank stability (for PageRank and Node2Vec).
- *Financial Relevance:* Assessing how algorithm outputs align with market traits, such as sector cohesion, influence stability, and recommendation reliability.

All algorithms will be tested on the same synthetic market graphs under stable, volatile, and crash-like conditions. Comparing their results will reveal trade-offs between computational performance, interpretability, and market insight, helping determine which models best capture dynamic stock market behavior.