Social Network Analysis

INTRODUCTION

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Social Network Analysis

GENISIS

- Social Network Analysis convergence of applied research in sociology + social psychology + anthropology
- Developed independently by various researchers through empirical studies of various social settings
- Formal description of social groups found by many social psychologists of the 1940s
- Anthropologists found network representations useful in generalizing actual field observations

Social Network Analysis

- Some of the concepts of network analysis have come naturally from social studies
- 1950s network analysis began converge to a view that distinguishes network analysis from other approaches to sociological research
- Convergence facilitated by the adoption of a graph representation of social networks by Moreno

Social Network Analysis

- Moreno called a *sociogram* was a visual representation of social networks as a set of nodes connected by directed links
- Explored how relations are beneficial and limitations for psychological behavior
- His journal *sociometry* investigated the relationship between psychological well-being and "social configurations”

Social Network Analysis

- John Barnes first introduced the term “Social network” (Barnes, 1954), did formal development of the analysis of social structures
- Barnes was the first to use the concept of social networks in a scientific context – political system, pattern of life, system of kinship and affinity
- In 1954, he published the article "Class and Committees in a Norwegian Island Parish"
- Tremendous increase in the capabilities of network analysis mostly through new applications and the vocabulary, models and methods of network analysis

Social Network Analysis

Two developments led to an explosion of SNA

- First, advances in information technology brought a wealth of electronic data
- Second, Methods of SNA applied to networks other than social networks E.g. Hyperlink structure on the Web or the electric grid
- The reason for adoption in other networks, share a number of commonalities with social networks

Social Network Analysis

What is Social Network?

- It is the study of social relations among a set of actors
- Focus is on relationships between actors than actors itself

Example: Performance of a researcher assessed by count of publications than attributes like grant possessed, age, size of team…

Social Network Analysis

- A statistical analysis relates attributes to outcome variable (the number of publications)

- Analysing social structures identifies presence / absence of relationship patterns

- Example: For researcher, arrangement of relationship in certain pattern is good to his performance than pattern not present

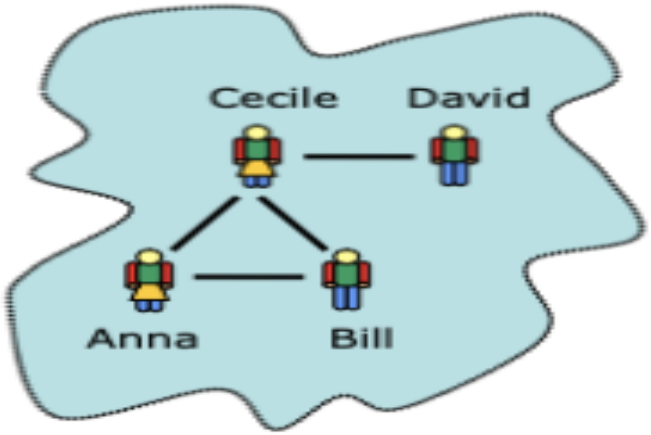
$M \coloneqq (m_{i,j})_{n*n}\ m_{i,j} = \begin{cases} 1 \mid (v_i,\ v_j) \in E \\ 0 \mid otherwise \end{cases}$

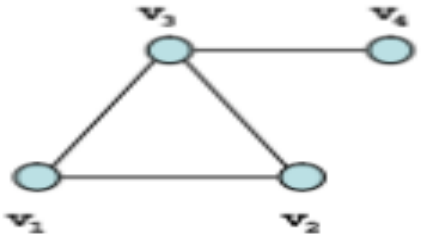
Social Network Analysis

- SNA needs new concepts and methods for data collection and analysis
- Methods of analysis originate from graph theory as social network data represented as graph
- A social network can be represented as a graph G = (V, E), V denotes the finite set of vertices and E denotes a finite set of edges such that $E \subseteq V \times V$

Characteristic matrix of the graph $M \coloneqq (m_{i,j})_{n*n}\ m_{i,j} = \begin{cases} 1 \mid (v_i,\ v_j) \in E \\ 0 \mid otherwise \end{cases}$

Social Network Analysis





	v_1	v_2	v_3	v_4
v_1	0	1	1	0
v_2	1	0	1	0
v_3	1	1	0	1
v_4	0	0	1	0

- *Loops* are not excluded rarely in occur in practical social network data sets (diagonal of matrix is empty)

- In case of multiple component in a graph, one component is chosen for analysis

The global structure of network

Most real world network are represented as abstract graph representation

Questions:

Are there any interesting feature in social network could impose on existing graph models?

Are there any kind of special graph occur in social network?

Social Network Analysis

- American psychologist Stanley Milgram experimented on the structure of social network

- Milgram found that the world around us to be small

"we routinely encounter persons not known to us who turn out to be the friends of our friends"

- Milgram's ***Six degrees of separation*** gives *Average distance between any two individuals in the world*

Graph measures of Milgram

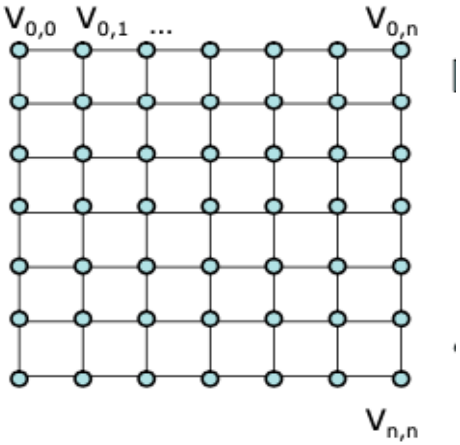
characteristic path length - average shortest path of the network

Geodesic - The shortest path between two vertices is also called a *geodesic*

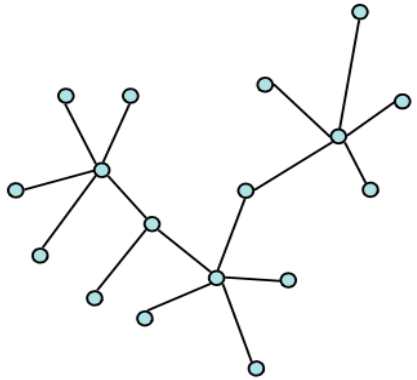
Diameter of the graph - The longest geodesic in the graph

Average shortest path not possible for weakly connected graph

Social Network Analysis



2D Lattice



Tree Graph

Milligram excluded certain structures as models for social graph E.g. 2D Lattice, tree graph

In tree graph all nodes have exactly one edge connected and no loops

In real life people socialize in group but Tree graph shows no clustering

Social Network Analysis

$$\text{Clustering of single vertex} = \frac{\text{actual no. of edges between the neighbors of a vertex}}{\text{possible number of edges between the neighbors}}$$

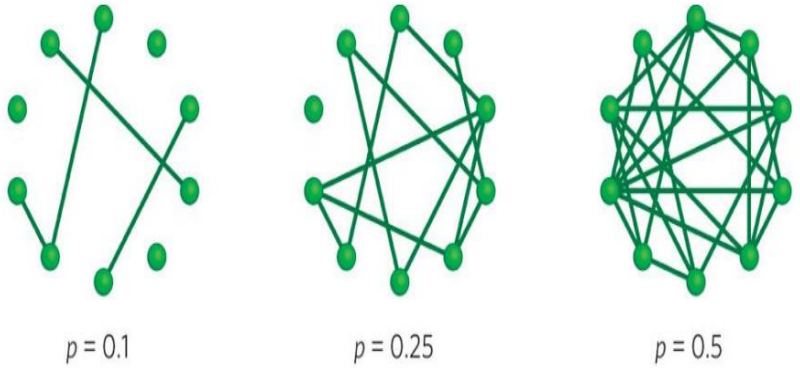
- Clustering coefficient is the average of clustering of all vertex
- Clustering coefficient of a tree is zero (no triads in a graph)

1. **Random Graph Model**:
   - Proposed by Erdős and Rényi.
   - Starts with isolated vertices and gradually adds edges with a certain probability.
   - Increasing the probability results in networks with small characteristic path lengths and some clustering.
   - Although it has limitations in accurately representing real-world networks, it's valuable for studying basic network properties and emergence.
2. **Alpha Model**:
   - Introduced by Strogatz and Watts.
   - The likelihood of forming a new connection between two nodes depends on the number of mutual friends they share.
   - The parameter "alpha" fine-tunes the influence of mutual friends on connection probability.
   - Successfully generates networks with small path lengths and substantial clustering coefficients, capturing characteristics of real-world social networks.
3. **Beta Model**:
   - A generative model that starts with a one-dimensional lattice.
   - Nodes are connected to neighbors and neighbors of neighbors.
   - Rewires links with a probability parameter "beta," leading to small path lengths and relatively high clustering coefficients.
   - Useful for creating networks with both local and global structure.
4. **Scale-Free Graphs**:
   - Proposed by Barabási.
   - Alpha and beta models fail to replicate the scale-free property of degree distributions.
   - Scale-free networks exhibit a power-law degree distribution, where a few nodes have many connections while most have only a few.
   - Common in real networks like co-authorship networks and the World Wide Web.
   - The "rich get richer" principle explains the emergence of scale-free structures.
   - Analyzing these models helps researchers understand network vulnerabilities ar
     spread of information or failures within them.

Social Network Analysis

Random Graph Model

- Generative graph proposed by Hungarian mathematicians Erdő́s and Ré nyi
- Initially start with set of vertices with no edges connected
- Subsequently add edges picking pair of nodes with certain probability
- Increasing the probability, results in small characteristics path and exhibits some clustering



Social Network Analysis

- Random graph model failed as unlikely to make friends completely in random from anywhere in the world
- Yet random graphs are used to study complex structures emerges through elementary Interactions

Alpha Model

- Proposed by Steven Strogatz and Duncan Watts in 1999 in a seminal paper

- No. of mutual friends shared by any two nodes determines the likelihood of a new tie

- Parameter alpha fine-tunes the influence of the number of friends on the probability of a tie

- It successfully generates graphs with small path lengths and large clustering coefficients

Social Network Analysis

Beta Model

The beta-model is also generative model

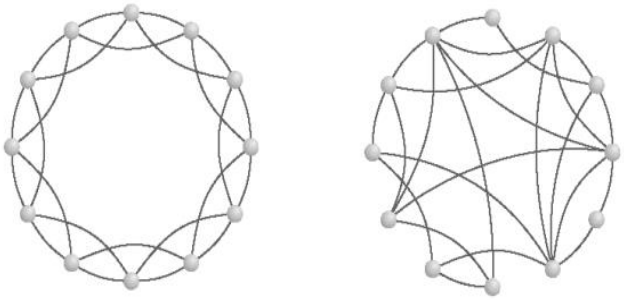
It starts with a one-dimensional torroidal lattice

Every node is connected to its neighbors and the neighbors of its neighbors

One end edge fixed and the other end reassigned randomly selected node

Process continued and rewires every link with a probability of a parameter beta

Choosing appropriate beta, model generates networks with small path lengths and relatively large clustering coefficients



Scale-free graphs

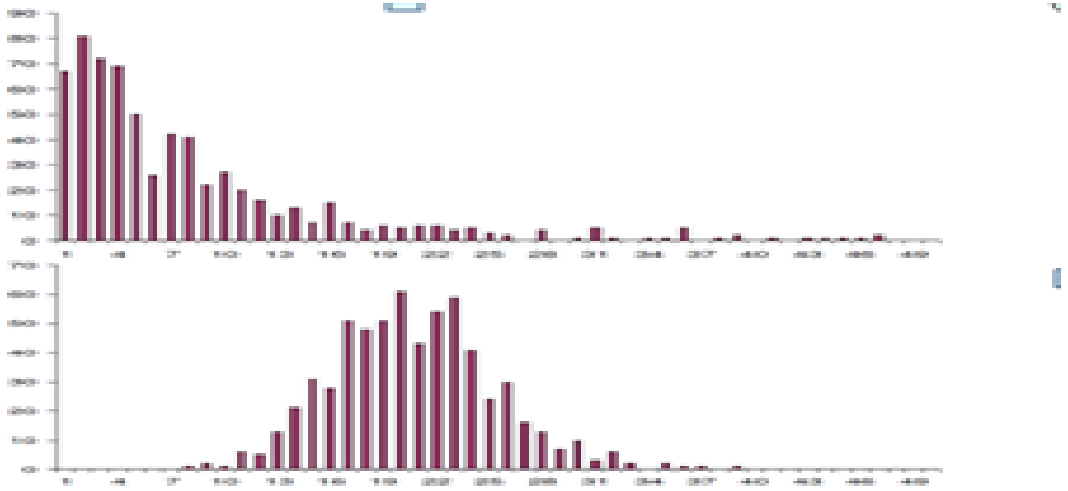
- Proposed by Hungarian physicist Albert-L´aszl´o Barab´asi
- Alpha and beta model failed to recreate scale-free characteristic of the degree distribution
- Distribution is normal in alpha and beta models and random graphs
- Real social networks, nodes with highest degree is less than nodes with small degree

Social Network Analysis

- Exactly correlates power law, i.e. $p(d) = d^{-k}$ where $k > 0$ is a parameter of the distribution

- i.e. a small amount of occurrences is common, while larger occurrences are rare

Example: Co-author network, few researchers have more co-authors and most have one or two co-authors



Social Network Analysis

• Small world phenomenon and scale-free characteristics found in many networks in nature

• Wikipedia, gene network, internet, hyperlink structure of the WWW or the electrical transport network exhibit scale-free characteristics

• *The rich get richer logic creates scale-free structures*

• By analyzing the model instead of particular instances of it allows scientists to formulate general claims about these networks

Example: vulnerability to specific kind of attacks or the possibility for the spread of viruses or failures across them

Social Network Analysis

Summary

- Social Network is amalgamation of sociology + social psychology + anthropology
- Breakthrough in Social Network adoption of a graph representation of social networks by Moreno
- Social Network Analysis is the study of social relations among a set of actors
- Various models developed to represent the behaviour of social network - Random, Alpha, Beta models
- Scale free graphs by Albert-L´aszl´o Barab´asi able to explain exact nature of social network (power law)