TA6

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Application fields

Mathematics, science and technology

Biochemistry (genomics)

Electrical engineering (communication networks and coding theory)

Computer science (algorithm and computation)

Operations research (scheduling)

Social science

Marketing

Economics

Finance

In Biology

- Identifying and modelling the structure of bio-molecular networks

Chen, Luonan, et al. *Modeling biomolecular networks in cells: structures and dynamics*. Springer Science & Business Media, 2010.

Alur, Rajeev, et al. "Hybrid modeling and simulation of biomolecular networks." *International workshop on hybrid systems: Computation and control*. Springer, Berlin, Heidelberg, 2001.

Li, Xiangyi, et al. "Biomolecular network-based synergistic drug combination discovery." *BioMed research international* 2016 (2016).

Chen, Luonan, Rui-Sheng Wang, and Xiang-Sun Zhang. *Biomolecular networks: methods and applications in systems biology*. John Wiley & Sons, 2009.

Liu, Rui, et al. "Identifying critical transitions and their leading biomolecular networks in complex diseases." *Scientific reports* 2.1 (2012): 1-9.

In Biology

Systems-level insights into cellular regulation: inferring, analysing, and modelling intracellular networks

- **Author(s):** C. Christensen ; J. Thakar ; R. Albert
- **Source:** IET Systems Biology, Volume 1, Issue 2, p. 61 –77
- **DOI:** 10.1049/iet-syb:20060071
- **Type:** Article

Graph theory and networks in Biology

- **Author(s):** O. Mason and M. Verwoerd
- **Source:** IET Systems Biology, Volume 1, Issue 2, p. 89 –119
- **DOI:** 10.1049/iet-syb:20060038
- **Type:** Article

Efficient algorithms for ordinary differential equation model identification of biological systems

- **Author(s):** P. Gennemark and D. Wedelin
- **Source:** IET Systems Biology, Volume 1, Issue 2, p. 120 –129
- **DOI:** 10.1049/iet-syb:20050098
- **Type:** Article

Analysis of lactose metabolism in E.coli using reachability analysis of hybrid systems

- **Author(s):** Á. Halász ; V. Kumar ; M. Imieliński ; C. Belta ; O. Sokolsky ; S. Pathak ; H. Rubin
- **Source:** IET Systems Biology, Volume 1, Issue 2, p. 130 –148
- **DOI:** 10.1049/iet-syb:20060035
- **Type:** Article

In Physics & Chemistry

In condensed matter physics, the three-dimensional structure of complicated simulated atomic structures can be studied quantitatively by gathering statistics on graph-theoretic properties related to the topology of the atoms.

Also, "the Feynman graphs and rules of calculation summarize quantum field theory in a form in close contact with the experimental numbers one wants to understand.

In statistical physics, graphs can represent local connections between interacting parts of a system, as well as the dynamics of a physical process on such systems.

In chemistry a graph makes a natural model for a molecule, where vertices represent atoms and edges bonds. This approach is especially used in computer processing of molecular structures, ranging from chemical editors to database searching.

Graphs are also used to represent the micro-scale channels of porous media, in which the vertices represent the pores and the edges represent the smaller channels connecting the pores.

Chemical graph theory uses the molecular graph as a means to model molecules. Graphs and networks are excellent models to study and understand phase transitions and critical phenomena. Removal of nodes or edges leads to a critical transition where the network breaks into small clusters which is studied as a phase transition. This breakdown is studied via percolation theory.

In Neuroscience

In computational neuroscience graphs can be used to represent functional connections between brain areas that interact to give rise to various cognitive processes, where the vertices represent different areas of the brain and the edges represent the connections between those areas.

Minati, Ludovico, et al. "From brain topography to brain topology: relevance of graph theory to functional neuroscience." *Neuroreport* 24.10 (2013): 536-543.

Farahani, Farzad V., Waldemar Karwowski, and Nichole R. Lighthall. "Application of graph theory for identifying connectivity patterns in human brain networks: a systematic review." *frontiers in Neuroscience* 13 (2019): 585.

Hallquist, Michael N., and Frank G. Hillary. "Graph theory approaches to functional network organization in brain disorders: A critique for a brave new small-world." *Network neuroscience* 3.1 (2018): 1-26.

DelEtoile, Jon, and Hojjat Adeli. "Graph theory and brain connectivity in Alzheimer's disease." *The Neuroscientist* 23.6 (2017): 616-626.

Vecchio, Fabrizio, et al. "Cortical connectivity and memory performance in cognitive decline: A study via graph theory from EEG data." *Neuroscience* 316 (2016): 143-150.

In electrical and electronics

Graph theory plays an important role in electrical modeling of electrical networks, here, weights are associated with resistance of the wire segments to obtain electrical properties of network structures.

Atkins, Karla, et al. "The structure of electrical networks: a graph theory based analysis." *International journal of critical infrastructures* 5.3 (2009): 265-284.

Dörfler, Florian, John W. Simpson-Porco, and Francesco Bullo. "Electrical networks and algebraic graph theory: Models, properties, and applications." *Proceedings of the IEEE* 106.5 (2018): 977-1005.

Deo, Narsingh. *Graph theory with applications to engineering and computer science*. Courier Dover Publications, 2017.

Piovanelli, Enrico, et al. "Towards a simplified estimation of muscle activation pattern from mri and emg using electrical network and graph theory." *Sensors* 20.3 (2020): 724.

Lekbich, Anass, et al. "An analytical multicriteria model based on graph theory for reliability enhancement in distribution electrical networks." *International Journal of Electrical and Computer Engineering* 9.6 (2019): 4625.

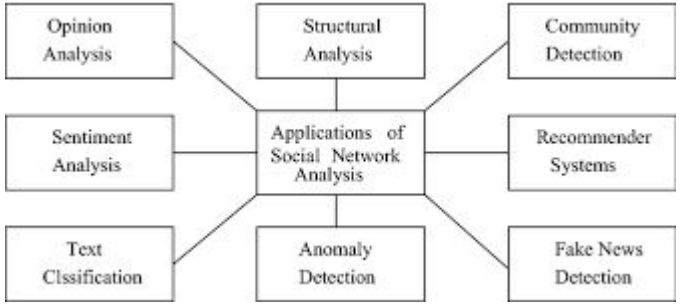
In social science

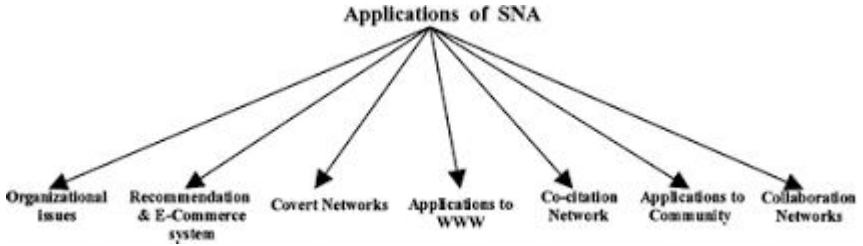
Social network analysis

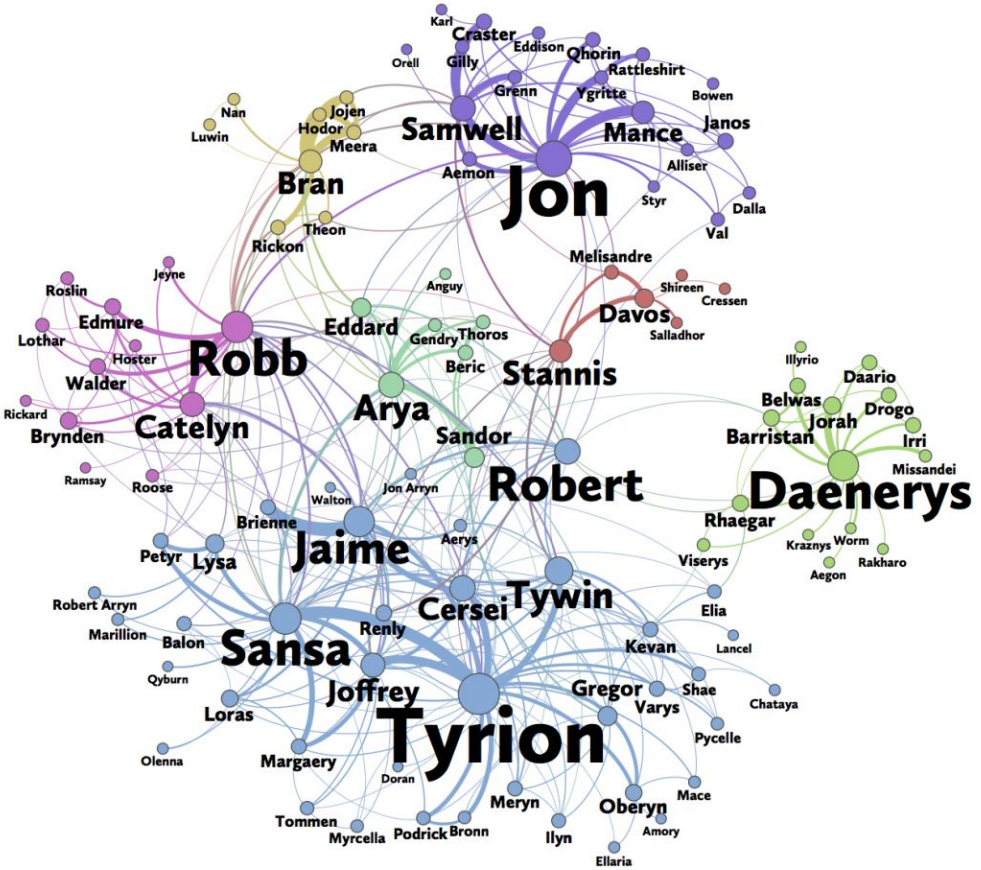
Social network analysis (**SNA**) is the process of investigating social structures through the use of networks and graph theory. It characterizes networked structures in terms of *nodes* (individual actors, people, or things within the network) and the *ties*, *edges*, or *links* (relationships or interactions) that connect them.

Can include social media networks, memes spread, information circulation, friendship and acquaintance networks, business networks, knowledge networks, difficult working relationships, social networks, collaboration graphs, kinship, disease transmission, and sexual relationships.

Social network analysis has emerged as a key technique in modern sociology. It has also gained significant popularity in the following - anthropology, biology, demography, communication studies, economics, geography, history, information science, organizational studies, political science,public health, social psychology, development studies, sociolinguistics, and computer science and is now commonly available as a consumer tool.







Game of thrones example

In social science

Wasserman, Stanley, and Katherine Faust. "Social network analysis: Methods and applications." (1994).

Baggio, Rodolfo, Noel Scott, and Chris Cooper. "Network science: A review focused on tourism." *Annals of Tourism Research* 37.3 (2010): 802-827.

Lusher, Dean, Garry Robins, and Peter Kremer. "The application of social network analysis to team sports." *Measurement in physical education and exercise science* 14.4 (2010): 211-224.

Pryke, Stephen D. "Analysing construction project coalitions: exploring the application of social network analysis." *Construction management and economics* 22.8 (2004): 787-797.

Hung, Man, et al. "Social network analysis of COVID-19 sentiments: Application of artificial intelligence." *Journal of medical Internet research* 22.8 (2020): e22590.

Parise, Salvatore. "Knowledge management and human resource development: An application in social network analysis methods." *Advances in developing human resources* 9.3 (2007): 359-383.

Chong, Alain Yee Loong, et al. "Predicting online product sales via online reviews, sentiments, and promotion strategies: A big data architecture and neural network approach." *International Journal of Operations & Production Management* (2016).

Spam and fake news

Shehnepoor, Saeedreza, et al. "NetSpam: A network-based spam detection framework for reviews in online social media." *IEEE Transactions on Information Forensics and Security* 12.7 (2017): 1585-1595.

Jang, S. Mo, et al. "A computational approach for examining the roots and spreading patterns of fake news: Evolution tree analysis." *Computers in Human Behavior* 84 (2018): 103-113.

Ciampaglia, Giovanni Luca. "Fighting fake news: a role for computational social science in the fight against digital misinformation." *Journal of Computational Social Science* 1.1 (2018): 147-153.

Shrivastava, Gulshan, et al. "Defensive modeling of fake news through online social networks." *IEEE Transactions on Computational Social Systems* 7.5 (2020): 1159-1167.

Benamira, Adrien, et al. "Semi-supervised learning and graph neural networks for fake news detection." *2019 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*. IEEE, 2019.

Nguyen, Van-Hoang, et al. "Fang: Leveraging social context for fake news detection using graph representation." *Proceedings of the 29th ACM international conference on information & knowledge management*. 2020.

Sivasankari, S., and G. Vadivu. "Tracing the fake news propagation path using social network analysis." *Soft Computing* (2021): 1-9.

Shu, Kai, H. Russell Bernard, and Huan Liu. "Studying fake news via network analysis: detection and mitigation." *Emerging research challenges and opportunities in computational social network analysis and mining*. Springer, Cham, 2019. 43-65.

Reviews

Havlin, Shlomo, et al. "Challenges in network science: Applications to infrastructures, climate, social systems and economics." *The European Physical Journal Special Topics* 214.1 (2012): 273-293.

Gosak, Marko, et al. "Network science of biological systems at different scales: A review." *Physics of life reviews* 24 (2018): 118-135.

Barabási, Albert-László. "Network science." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 371.1987 (2013): 20120375.

Smith, Edward Bishop, et al. "Social networks and cognition." *Annual Review of Sociology* 46.1 (2020): 159-174.