Network research needs to focus on temporality and weightedness

October 5 2012

The study of complex networks in statistical physics and computational science has become more and more focused on so-called dynamic networks. Where traditional approaches have treated the links in networks as static, contemporary research looks into their development in time and into the individual properties of the links.

Mikko Kivelä, defending his doctoral dissertation for the Aalto University Department of Biomedical Engineering and Computational Science, presents several novel methods for the computational research of dynamic, weighted and temporal networks.

"Complex systems are studied on a system-wide scale instead of focusing on each composing part and interaction. This way they display emergent behaviour: patterns and structures, which would be impossible to predict based on single interactions alone, begin to appear, Kivelä explains the basics of his research."

Clustering reveals densities in networks

In weighted networks links are not all alike but have different strengths. Social networks, gene networks, connections between brain areas or networks representing price correlations in stock markets can all be treated as weighted networks.

Together with his colleagues in the Department of Biomedical

Engineering and Computational Science, Kivelä studied different methods for the search of dense parts in weighted networks. So-called clustering coefficients enable the analysis of the construction and the functioning of networks.

"We compared ways to generalise the clustering coefficient for weighted networks. Our results help to choose the right way to measure clustering for networks weighted in different manners, Kivelä affirms."

The methods have already been widely used in the research of the human brain, for example.

Locating dense community structures – clusters – in networks was performed in Kivelä's research with a method called clique percolation. Clusters may be groups of friends in social networks or groups of close genetic kin in ecological networks.

"We used clique percolation in a new way to make the clusters more accurately represent the actual structure of the network. The search for clusters is now also computationally more powerful thanks to the new algorithm we constructed. Now the method can be used on extremely large network data."

A temporal perspective to network topology

Information presumably travels quickly through a network if it is a 'small world', that is, the majority of the nodes are only a couple of links apart. However, Kivelä discovered that the burstiness of temporal networks significantly slows down the spreading speed.

Burstiness is typical for human communication for instance: short but intensive episodes of activity are followed by long uneventful intermissions in mobile phone and email communication.

Kivelä has studied the spreading of information in bursty temporal networks with null models. He used them to remove features from a database of over 300 million mobile phone calls – circadian patterns and the bursts of the calls among others – until only the basic network structure of the phone calls remained.

"Thus we could discern which properties of the temporal network affect the spreading speed of information. We clearly demonstrated that the bursts slow down the spreading process. We were also able to measure the spreading in the bursts of individual links."

Kivelä suggests that the analysis of complex networks would benefit from a focus on the temporal behaviour and the specific properties of individual links, for instance in social networks. In this respect, Kivelä's dissertation provides increasingly nuanced understanding of complex networks.

"The specifics of the people between whom bursts occur, and the way bursts are linked to network topology, are mainly unknown as of yet. Also the temporal perspective to the behaviour of networks is still lacking knowledge, Kivelä sketches the direction of future research in the field."

More information: M.Sc. (Tech.) Mikko Kivelä will defend the dissertation "Weighted and Temporal Networks: Towards More Realistic Representations of Complex Systems" on 5 October 2012. Location: Lecture hall F239a, Otakaari 3, 02150, Espoo

Provided by Aalto University