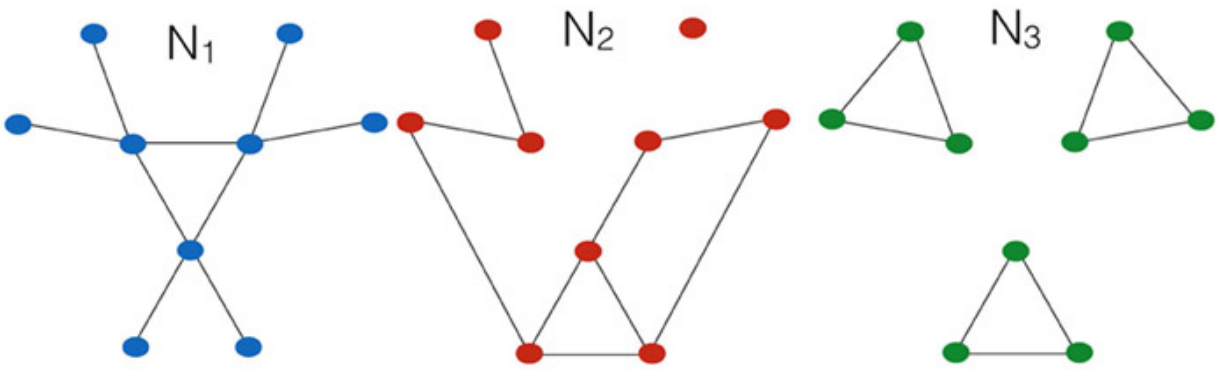
Scientists develop new high-precision method for analysing and comparing functioning and structure of complex networks

February 22 2017



Credit: Universitat Politècnica de Catalunya (UPC)

Researchers at the Universitat Politècnica de Catalunya (UPC) and the University of Barcelona (UB) published a paper in *Nature*

Communications presenting a scientific method for identifying, comparing and precisely determining objective differences between large nodes of complex networks.

The new method makes it possible, for example, to compare and differentiate the functioning of brain networks in drug addicts and healthy individuals, thus advancing the study of the symptoms and effects of addiction on the brain. The method can also be used to more effectively analyse the functioning of critical complex systems, such as power distribution networks, airport connections and even social networks like Facebook and Twitter.

Researcher Cristina Masoller explained the advantages of the new approach: "Imagine you have a power distribution system consisting of two interconnected networks, each with the same number of links, and one network loses a link because of a breakdown. With the methods we've had up until now, it's only been possible to determine the difference due to that missing link. With our method, we can also determine the precise location of the lost link and its importance in relation to the system—that is, whether its absence will significantly hinder the distribution of power."

Currently, it is very difficult to differentiate, distinguish and compare the functioning and structure of networks that have hundreds of thousands of interconnected nodes and form so-called complex systems. This is true of brain networks and connections. Understanding their structures, determining differences between connections and diagnosing dysfunctions are complex tasks. Until now, there was no precise and effective way to recognise the presence or absence of critical links that connect or disconnect network components, because if they are not identified, it is difficult to ensure that they are functioning properly in the transmission of information.

According to Masoller, "That's why our method is a significant advance in the study of complex systems. It indicates, with a high degree of precision, how important failed connections are in relation to the functioning of a complex system." In addition to identifying and naming the nodes in a network, "We can reliably calculate the distances between the points it comprises. Thanks to mathematics, we've pulled it off. Now scientists have a useful tool for studying complex systems with more certainty and precision," said the UPC researcher.

According to UB researcher Díaz-Guilera: "Our method also makes it possible to find out how a particular topological feature was formed. Defining the distance between networks allows us to generate virtual networks based on specific mathematical models and see which one gets us closest to reality. Networks that expand based on geographical proximity, such as transport networks, are different from those whose growth is driven by affinity, such as social networks. Understanding how a network was formed, based on these mathematical models, allows us to determine what its strengths and vulnerabilities will be."

The methods available to the scientific community up until now could be used to detect a difference in the number of connections in a network or even to determine the number of connections that were not working, but existing methods could not be used to work out the location of damaged connections or whether they were really interrupting the flow of information in the network as a whole.

More information: Tiago A. Schieber et al. Quantification of network structural dissimilarities, *Nature Communications* (2017). DOI: 10.1038/ncomms13928

Provided by Universitat Politècnica de Catalunya (UPC)