Abstract

Networks that are prevalent in modern society, such as electric power networks, communication networks, and social networking sites, can be abstractly represented as a set of nodes (points) and links (lines). These complex and large-scale networks share a common structure of being scale-free, characterized by a small number of hub nodes with many links and a large number of nodes with only a few links. However, these scale-free networks are also known to be highly vulnerable to attacks on their hub nodes, as the loss of just a few percent of all nodes can result in the loss of connectivity for the entire network.

Complex network science also focuses on resilience, which is the ability to maintain functionality after an attack or disruption. Resilience involves adapting to changes in the environment by reorganizing and restructuring structures and processes to enable sustainable development. In the case of scale-free networks, such as real-world networks, simply repairing a damaged network and restoring it to its original state is not enough to achieve a resilient network. The key is to have a self-healing method that can construct a more robust network after restoration, thus addressing the structural fragility inherent in scale-free networks. As previously stated, many of the networks that support modern society are highly vulnerable due to their scale-free structure. In order to achieve a resilient society that can withstand unpredictable crises such as disasters, it is essential to design systems that consider network fragmentation and recovery, such as in the case of attacks and self-healing.

However, the attack and repair processes of networks can be difficult for non-experts in network science to understand. Therefore, it is important for both scientific research and society to develop methods and tools that enable non-experts in network science to comprehend the attack and self-healing processes of networks. Research on identifying network structures that are resilient against attacks and on developing methods for building such networks has primarily been conducted through numerical simulations. As a result, it can be challenging for non-experts in network science, such as those managing power grids at electric companies, to understand the outcomes of these simulations.

Therefore, it is crucial for non-experts to be able to intuitively grasp network resilience events, such as attacks and repairs, through simple diagrams of the relationships between nodes, which can be easily navigated using basic actions like mouse operation. This research aims to enhance understanding of the attack and repair of complex networks with real-world scale-free structures through the use of interactive visualizations. This includes the process of node deletion and the addition of new links to nodes.