Exploring partial synchronization in networked systems

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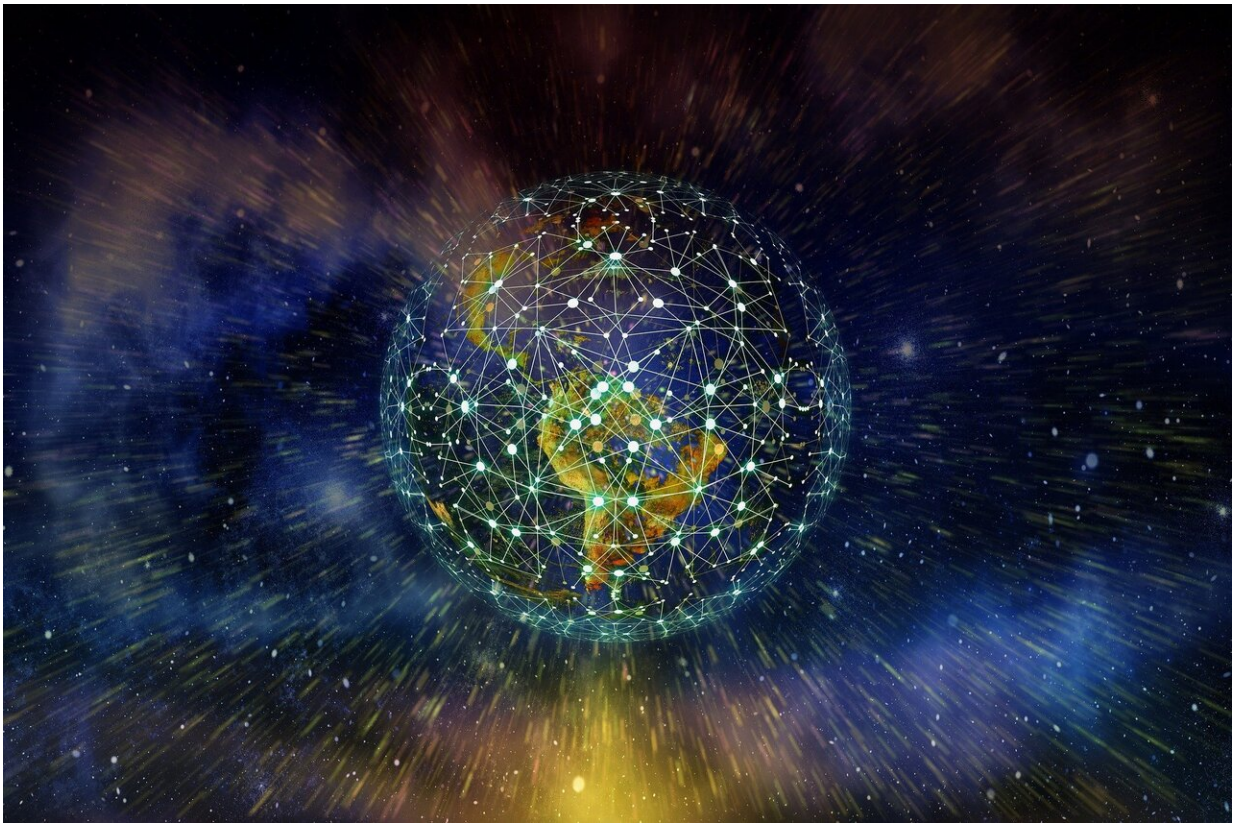

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Synchronization is all around us: from thousands of fireflies congregating near trees and lighting up simultaneously to an excited audience taking part in "Mexican waves" during a football match, and

the list goes on. In large, complex networks of interconnected systems, an incomplete form of synchronization is also present. Referred to as partial synchronization, it emerges such that systems can be grouped into clusters such that synchrony is only observed in each cluster. For his Ph.D. research, Libo Su has investigated partial synchronization in networks of dynamical systems that are interconnected via time-delay couplings. Su defended his Ph.D. thesis on May 11th at the department of Mechanical Engineering.

Synchronization can be seen flocks of geese during migration and in vehicles moving in platoons on roads. But Synchronization also plays a key role in human life. For example, heartbeats are regulated by clusters of synchronized pacemaker neurons, and blood sugar levels are maintained by the insulin secreted by the synchronized β-cells in the pancreas.

However, there are networks that do not exhibit full synchrony, and instead are typified by partial synchronization. In the human body, one example is synchronous behavior of groups of neurons in the certain parts of the brain, with these synchronies being important for specific brain functions such as memory formulation, language comprehension, and even disorders like epilepsy and Parkinson's disease.

Questioning partial synchronization

As part of his Ph.D. research, Libo Su explored partial synchronization in networks of dynamical systems that are interconnected via time-delay couplings. He focused on addressing three particular mysteries with regards to partial synchronization. First, what are the possible partial synchronization patterns that can be observed in a network? Second, when will a certain pattern of partial synchronization emerge in a network? Finally, how robust is the partial synchronization with respect to perturbations?

Factors such as network structure, coupling function, and the dynamics of the individual systems all play a role in formulating a form of partial synchronization in the networks studied by Su. A major challenge for the research is to find the relationship between these factors and partial synchronization.

Valuable insights

In ddressing the aforementioned research questions, Su provides an efficient method to identify all partial synchronization patterns and conditions for the occurrence of partial synchronization in both nominal and perturbed cases. In return, the method and conditions provide valuable insights into the relation between the dynamics of individual systems, coupling parameters, time-delays, and partial synchronization.

These theoretical results are demonstrated by experiments with an electronic "brain" (a network of electronic neurons). In collaboration with TNO, Su also demonstrated another example of a real-life application of synchronization in networked systems—vehicle platooning.

More information: Title of PhD-thesis: A study of partial synchronization in networks of delay-coupled systems. Supervisors: Prof.dr. Henk Nijmeijer (TU/e), Prof.dr.ir. Wim Michiels (KU Leuven), Co-supervisor: Dr.ir. Erik Steur (TU/e). Other main parties involved: European Union (Marie Curie project UCoCoS), KU Leuven, TNO.

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https://techxplore.com/news/2021-05-exploring-partial-synchronization-networked.html