Physics Model Determines Dynamics of Friends and Enemies

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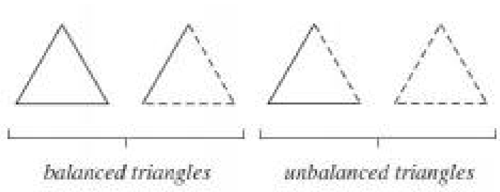

In these socially balanced and unbalanced configurations of a triangle, solid edges represent friendly relationships, and dashed edges hostile relationships. Image credit: Marvel, et al.

(PhysOrg.com) -- Sometimes friends can become enemies and enemies become friends, and it’s difficult to understand exactly how or why the changes took place. A new study shows that when the shifting of alliances and rivalries is interpreted using principles from social psychology, the overall behavior can be modeled as arising from an energy minimization process. The work is part of a growing line of research that uses tools from physics to analyze complex social systems.

In their study, Seth Marvel, Steven Strogatz, and Jon Kleinberg from Cornell University have used theories from social psychology to classify certain configurations of friends and enemies as being more stable than others. They show that these configurations can be represented by an energy landscape, in which the overall social stress corresponds to a kind of energy that relaxes as relationships shift between friends and enemies.

In their model, the researchers used plus signs to represent friendships between two individuals, and minus signs when two individuals were enemies. Some configurations in a group were considered balanced, while others were unbalanced. For example, in a balanced configuration, the enemy of your enemy should be your friend, and the friend of your enemy should be your enemy. In the scientists' model, these balanced configurations require less energy to maintain, and are the global minima in the energy landscape. The configurations of lowest possible energy are those in which all pairs in the network are friends, or in which the network is divided into two "rival factions": two groups of mutual friends who are antagonistic toward each other.

While this description of the lowest-energy configurations has been studied in previous work, the researchers found that the overall energy landscape is more complex than previously thought. Specifically, they found that "jammed states," or local minima, occur when a configuration is trapped between adjacent configurations of higher energy, prohibiting it from moving toward the lowest energy state (a balanced configuration). When investigating the structure of these jammed states, the researchers found that these states form more often at lower energies, and higher-energy jammed states are structurally more complex than lower-energy jammed states.

"Earlier work by Antal, Krapivsky, and Redner had shown that jammed states could exist, and so our interest was in developing a more complete picture of the possible energy levels and structures of these jammed states," Kleinberg said said to *PhysOrg.com*. "We find that jammed states can exist at surprisingly high energies, and that the pattern of friend/enemy relationships within a jammed state has an inherent complexity that increases as we move higher up the energy landscape."

These results provide a first look at how social networks can be viewed as energy landscapes that are driven by minimizing social stress (or, by the same token, increasing consistency in relationships). While this study reveals insight into the landscape's local and global minima, in the future the researchers hope to better understand the large-scale structure. By doing so, they could possibly find pathways leading from the most entrenched conflicts toward states of reconciliation.

"Our model is a theoretical one; it explores the consequences that follow logically from a few simple principles in social psychology, and it shows that these consequences can be surprisingly complex," Kleinberg said. "We think it could help provide a guiding framework for reasoning about real-life social networks in which there is both friendship and conflict, and in particular it could provide a useful perspective for subsequent empirical studies aimed at interpreting the patterns of friend and enemy relations that one finds in real data."

More information: Seth A. Marvel, Steven H. Strogatz, and Jon M. Kleinberg. "Energy Landscape of Social Balance." *Physical Review Letters*, 103, 198701 (2009).