Description for the general public

Signed Relations and Structural Balance in Complex Systems: From Data to Models

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Nowadays the development of technology and the holistic view on science decreased the boundary between *hard* (e.g., mathematics, physics) and *soft* (e.g., sociology, psychology) sciences. New big datasets and the application of physics methods enabled broader approach to the analysis of the processes in the society, which led to fast development of interdisciplinary studies, e.g. sociophysics. Our project belongs to such research, since it combines the knowledge and methodology from physics and data exploration in order to verify hypothesis from psychology – **Heider's theory of structural balance**. To this end we apply among others statistical physics models of multi-body interactions and methods for their dynamics analysis.

Let us imagine the following case. We have two friends who don't like each other. Can we stay on good terms with both of them? Is it easy to organize a common meeting? According to the theory of structural balance such a system is unbalanced and existing conflicts will drive system's evolution towards decreasing tensions. Going back to above example one of the friends could break the relation with us or thanks to our efforts they may become friends. Theory of structural balance claims that a system of agents (i.e., people, organizations) is balanced, when following four rules are fulfilled: "friend of my friend is my friend", "friend of my enemy is my enemy", "enemy of my friend is my enemy" and "enemy of my enemy is my friend". Above rules were *translated* to the language of complex networks. *Signed networks* were used. These are the structures of agents (nodes) and links (edges) connecting them, where all the links are assigned a positive or negative sign. Such a **signed relation** corresponds to positive or negative **relations** among agents.

Past research in sociophysics and social sciences verified the hypothesis of structural balance theory only in very limited fashion. Such studies needs proper data, that is difficult to obtain and in consequence rare. Usually real data on social networks include, for instance, only information about conversations or face-to-face interactions. The information about signed relations is missing. In this project we will create methods on how to extract link signs from data about how people interact between themselves. Obtaining **real data** of signed networks will let us study the evolution of structural balance. Past research suggests such systems are close to being balanced, but never are. That's why the next goal of this project is building **agent based models** of social systems, that will let us understand how the relations between people evolve and influence their behavior. Is structural balance really playing an important role in social relations? Or is similarity of opinions more important? Do we speak with *friends* more frequently than we quarrel with *enemies*? If we know who talks with whom, can we determine who is a friend and who is a foe, without knowing topics of the discussions? To answer above questions we will apply network models of agents possessing attributes describing their characteristic features (e.g., age, ethnicity, opinions), similar to models of magnetic materials or other multi-body models in statistical physics. In the last step we will verify whether created **models** describe real human behavior observed in different **data sets** well. Since humans behave differently in various situations, we will first need to calibrate our models in order to describe behavior in different situations. Model analysis will let us better understand what influences social interactions and evolution of human relations. In particular, we will learn which of many possible mechanisms are significant and which are not, especially whether structural balance theory has significant impact on decisions who is our friend and who is not.

Summing up, in this project we will apply methods of statistical physics and data exploration to create new methods and models giving rise to better understanding how interactions among humans translate to their relations and vice versa, and how these relations change in time.