Modeling Socio-Psychological Behaviors in the Era of the WWW: a Brief Overview

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Abstract. The World Wide Web has deeply changed our world and, over years, it has shaped our society. Social networks like Facebook strongly speed up the spreading of information among users, and allow people to communicate simultaneously with several individuals. As result, when studying sociological phenomena and socio-psychological behaviors, we have to consider the influence that the WWW has on people's life. In this work, we briefly present some computational models that can be adopted for representing socio-psychological behaviors in this scenario.

Keywords: evolutionary game theory, sociophysics, human behavior

1 Introduction

Sociophysics [1, 2] is a modern research field focused on investigations of socio-economic systems by means of computational and analytical models. Just to cite few, sociophysics deals with opinion dynamics [1, 2], language dynamics [3, 4], crowd dynamics [2], economy [5].Notably, simple models like the voter models [6] are able to represent simplified scenarios of opinion spreading, and to identify exact solutions. Although these analytical approaches often require a high level of abstraction compared to the real scenarios (e.g., electoral campaigns), they allow to introduce a mathematical formalism to study social issues. Moreover, agent-based models constitute a powerful framework —see [7] for modeling social dynamics, that can be combined with the modern network theory [8]. It is worth to recall that a list of qualitative models, developed in sociology and in social psychology, has been analyzed under the lens of statistical physics. In the last years, the WWW has deeply shaped our society and, in general, the life of several people.Therefore, both sociology and social psychology have to consider this modern world when studying social phenomena and behaviors. In the light of these considerations, in this work we report a brief summary of some socio-psychological behaviors analyzed in the context of complex networks [8]. In particular, we consider relevant to identify computational models able to describe human behaviors because, although a lot of data (currently defined 'Big Data'), a general mathematical framework to deal with them still lacks.

2 Models

We briefly present two different study-cases to show how human behaviors strongly affects dynamics in social systems, as social networks in the WWW.

Competitiveness. In the proposed model [9], we study a population whose agents play the Prisoner's Dilemma (hereinafter PD) in a continuous space (see also [10]). In so doing, agents play the PD with their neighbors computed according to an interaction radius. In principle, the PD is a very simple game where agents behave as cooperators or as defectors and, according to a payoff matrix, they compute their payoff after each challenge. Notably, the payoff matrix of the PD can be defined as follows

$$\begin{array}{c} \\ C \\ D \end{array} \begin{array}{c} \begin{array}{cc} C & D \end{array} \\ \begin{pmatrix} 1 & S \\ T & 0 \end{pmatrix} \end{array} \quad (1)$$

The two strategies, i.e., cooperation (C) and defection (D), are grouped in the set $\Sigma = \{C, D\}$. Moreover, the parameter T represents the *Temptation*, i.e., the payoff gained by defectors when face cooperators, while parameter S the *Sucker's payoff*, i.e., the payoff obtained by cooperators when face defectors. Values of T and S are in the following range (in the PD): $1 \leq T \leq 2$ and $-1 \leq S \leq 0$. Results of numerical simulations can be studied by analyzing the TS-plane, computed on varying the value of S and T. In this scenario, it is interesting to analyze if a cooperative behavior emerges on varying S and T, when considering 'competitive' agents. Notably, agents have an interaction radius whose length depends on their payoff: as it increases/decreases their interaction radius increases/decreases. Thus, agents with high payoff become more competitive.Here, we consider the same geometrical framework of [11]) but with two main differences: *i)* agents cannot move and *ii)* agents may vary their interaction radius. Eventually, in all simulations we consider an equal initial distribution of strategies. Results, shown in panel **a** of Figure 1, suggest that 'competitiveness' strongly increases the level of cooperation in a population playing a game (i.e., the PD), characterized by an opposite Nash equilibrium (i.e., defection)

Group Polarization. Now we focus on the emergence of extreme opinions [12], by considering the theory of group polarization [13]. The latter is a collective phenomenon that occurs when groups of individuals are taking a decision. In order to model this phenomenon, in the context of social networks (and then of the WWW), we propose an agent-based model considering a system with 3 opinions: two opposite opinions and one representing the extreme form of one of them. For instance, opposite opinions may represent feelings pro-western (pw) and anti-western (aw), respectively, while the third opinion may represent the terrorist/passive supporter [14] ideal. Agents are arranged on a small-world network, so that they can interact with their neighbors; although we impose that they cannot change opinion from $+1$ (i.e., pw) to -1 (i.e., aw), and vice versa,

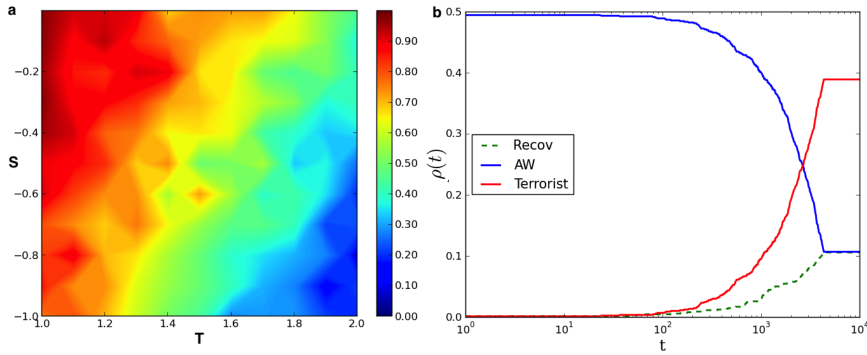

Fig. 1. a) Cooperation frequencies in the TS-plane achieved by agents provided with $\bar{k(0)} = 4$. Colors indicate the averaged degree of cooperation achieved by the population. We recall that red indicates strong cooperation, while blue defection (i.e., no cooperation) —see [9]. **b)** Density of agents having the opinions aw and Terrorist, over time. The density of aw agents decreases until it reaches the density of recovered ones (i.e., those who quit secret meetings) see [12].

over time. We suppose that one agent of the network is a terrorist (hereinafter TL), with an opinion $s = -2$ representing an extreme form of the anti-western feeling. Then, at each time step, TL tries to convince other agents, among those with the aw feeling, in order to organize meetings. Each aw agent accepts the invitation with probability $p^r \in [0, 1]$ (equal for all aw agents). As aw agents accept to attend secret meetings, new connections emerge among them, giving rise to the emergence of a sub-community (having a structure similar to a fully-connected network). According to the theory of 'group polarization', a small set of people with the same idea can be lead to take the idea to the extreme level; hence, a small set of aw agents risks to become terrorist due to the intra-interactions. The recruiting of aw agents is the underlying mechanism responsible for the variation of the social network. Considering the i-th recruited agent (i.e., one of the meetings' participants), its p^t (i.e., probability to become terrorist) and p^{out} (i.e., probability to quit to attend secret meetings) are computed as follows: $p_i^t = f(\sigma_i^-, \sigma_i^{--})$ and $p_i^{out} = \sigma_i^+$, with σ_i^- and σ_i^{--} densities of aw and terrorist agents in the social circle of the ith agent, respectively; and σ_i^+ density of pw agents in the social circle of the ith agent. The function $f(\sigma_i^-, \sigma_i^{--})$ has been devised in order to consider the presence of both aw and terrorist agents among neighbors of the ith agent. Results (see panel **b** of Figure 1) show that a high fraction of agents which takes part to meetings undergoes the phenomenon of group polarization.

3 Conclusions

In the era of WWW, the studying of social behaviors recovers a particular importance. Notably, our lives are strongly affected by social networks and all devices that are connected on Internet. Friendships and other human relations now are developed and supported by virtual connections that allow individuals to be connected with a wide list of people. As results, several socio-psychological behaviors must be analyzed in this new technological context. Moreover the increasing number of digital traces, currently defined as 'Big Data', still requires the definition of a formal mathematical theory. Thus, analytical and computational approaches for studying the evolution of social systems, considering human behaviors, may represent viable methods to investigate social network dynamics. With this idea in mind, we present a brief report about social behaviors modeled in the context of the WWW, showing their central role in the dynamics and in the evolution of a population.

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