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Activeness as a key to counter democratic balance

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HIGHLIGHTS

- We introduce a new attribute Activeness to build a variation of Galam model.
- We change the usual synchronous Galam model into an asynchronous Galam-A model.
- Population size is related to probability for "minority counteroffensive".
- Scattered opinion leadership works better than concentrated opinion leadership.

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ABSTRACT

According to the classic Galam model of opinion dynamics, each agent participates at each update of an opinion interaction. While the scheme gives everyone the same chance to influence others, in reality, social activity and influence vary considerably from one agent to another. To account for such a feature, we introduce a new individual attribute – "activeness" – which makes some agents more inclined than others at engaging in local discussions. To enhance the corresponding effect, opinion updates are shifted from all-out agent interaction cycles to few agent interaction cycles. Using dynamic analysis and simulations the resulting model is found to exhibit a "Minority Counteroffensive" phenomenon, which under some initial conditions makes the minority to win the opinion competition despite a threshold tipping point at fifty percent. The associated probabilistic phenomenon persists in the case "activeness" is held equal for all agents. The effect of "opinion leaders" is also investigated. Indeed, a leader is an inflexible agent, i.e., an agent who does not change opinion. The results reveal that two opinion leaders with moderate social influence may have a stronger effect than one opinion leader with a strong social influence. The model may shed a new light to the understanding of opinion formation and public voting.

1. Introduction

Sociophysics initiated in the 1980s [1] has now established as an active field of research mainly among physicists [2–5]. Opinion dynamics is a major topic of Sociophysics and has attracted much work with both discrete [6–13] and continuous models [14–16]. For the first group, a seminal two-state model of opinion spreading was introduced three decades ago by Galam [17]. Since then, a series of extensions have been implemented to make the Galam model more complete and suitable to describe real social situations. Up to date, those improvements include the contrarian effect [18], the occurrence of a tie in even group sizes [19], three competing opinions [20], the role of inflexible agents [21,22], with different group sizes [23], with differential latencies [24] and collective phenomenon [25].

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In all cases, the dynamics is implemented by iterated cycles at which the whole population is divided randomly into groups of one or different sizes. Then each group adopts the opinion of the local majority. This dynamic is called a randomly localized mechanism with a local majority rule [26–29]. The randomly localized mechanism is the essence of the Galam model. Under this mechanism, the opinion dynamic process can be represented by an evolution equation from which the landscape of the opinion flow is obtained by identifying associated attractors and separators.

In this work, a new individual feature of agents, "activeness", is introduced to account for the real-life differences in agent propensities to engage in local discussions with others. Such a feature breaks the original Galam update process where each agent has an equal probability to meet with other agents. Now, more active agents meet more often than other agents. To implement this reality the all-out randomly localized majority rule mechanism is reduced to a few agent interactions at a time. The resulting model denoted the Galam-A for activeness.

In addition, we also consider the effect of leaders according to their respective social influence measured by their respective activeness. Indeed, a leader is an inflexible agent, i.e., an agent who does not shift opinion. Calculations are performed in the case of groups of discussion with three agents.

In Section 2, after a brief review of the classic Galam model, the Galam-A model is defined. Section 3 concerns the study of the dynamic properties of the Galam-A model. Section 4 discusses simulations of the model, including the "minority counteroffensive" phenomenon and the effect of the "opinion leader". Last Section contains a short discussion.

2. The model

2.1. Galam model

This is a brief introduction of the classic Galam model, considering a population of N agents, each of which can have opinion A or B. At each time step, the whole population is divided into groups of size s, where each agent belongs to one and only one group. In this case, the local majority rule works: if more than half of the agents holds opinion A, all others will change their opinions to opinion A. Note that when $s = 3$, or any other odd number, ties are ruled out. The evolution equation for the fraction p_A of agents holding opinion A is:

$$p_A(t+1) = p_A^3(t) + 3p_A^2(t)(1 - p_A(t)). \quad (1)$$

The evolution exhibits two stable fixed points at $p_A = 0$ and $p_A = 1$, with a separation point at $p_A = \frac{1}{2}$. Therefore, in the classic Galam model, the initial majority will eventually win the opinion competition [13].

2.2. Galam-A model

The Galam-A model also studies a public issue in a population of N, for which two competing opinions, A and B, are available. However, different from the classic Galam model, each agent in the Galam-A model has two attributes: Opinion and Activeness. Opinion is a Boolean variable (1–0); a value of 1 indicates the holding of opinion A, and a value of 0 indicates the holding of opinion B. Activeness is a positive integer variable $(1, 2, 3\ldots)$, that is proportional to the probability of the agent's social influence. By the way, we use integer rather than float just for calculating convenience, it will not make a big difference. This differs from the classic Galam model in that at each time step, we choose only one group of size s to debate the opinion; the same local majority rule works. In another words, we turn the usual Galam model which is a synchronous into an asynchronous model.

O_k and A_k will be separately used to represent the Opinion and Activeness of the kth agent. The probability that the kth agent will be chosen is $\frac{A_k}{\Sigma_k A_k}$ and is proportional to the agent's Activeness. In some sense, this handling method is similar to models considering persuasive power [30–32]. The agent with relatively larger Activeness will have a higher probability to exchange an opinion with others. This process allows different agents to have different frequencies of possibility to interact with others in discussion groups. We treat the agents as nodes and the interaction relationships as the edges in a network. The differences between the Galam model and Galam-A model are shown in Fig. 1.

3. Model dynamics

S_A (S_B) are the sets of agents holding opinion $A(B)$, N_A (N_B) are the size of S_A (S_B), $N \equiv N_A + N_B$. Taking the Activeness into consideration, the probability of agent holding opinion A or B to be chosen are:

$$p_A = \frac{\sum_{k \in S_A} A_k}{\sum_{k \in S_A \cup S_B} A_k}, \qquad p_B = \frac{\sum_{k \in S_B} A_k}{\sum_{k \in S_A \cup S_B} A_k},$$

and $p_A + p_B \equiv 1$. From a population of N agents, we chose a group of 3 agents for each time step. The local majority rule still works. All possible opinion interaction situations are as follows: AAA $\rightarrow$ AAA, AAB $\rightarrow$ AAA, ABB $\rightarrow$ BBB and BBB $\rightarrow$ BBB. Only the AAB $\rightarrow$ AAA and ABB $\rightarrow$ BBB situations will cause an agent to shift its opinion from B to A or from A to B. We use $p(B \rightarrow A)$ and $p(A \rightarrow B)$, respectively, for the occurrence probability of the two kinds of opinion shifts.