

Evolutionary Dynamics of Collective Action Problems

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Abstract

In the study of a single rational individual, it is often straightforward to design a framework of rules and rewards to encourage a particular outcome that maximizes the individual's welfare. When it comes to groups of individuals, on the other hand, this is not guaranteed. Incentives for individuals do not always align with an optimal outcome for society as a whole, and it is misguided to treat a group as a single entity that thinks and behaves like its constituent members. This thesis uses mathematical tools to study aspects of collective action problems in three contexts: the distributed graph coloring problem, polarization and voting, and fake news in social networks.

Many scenarios require group members to specialize or differentiate themselves from those around them to maximize group effectiveness. In such situations, reaching a state of maximum global effectiveness may require individuals to make short-term sacrifices for the greater good when the group becomes "gridlocked." We use the mathematical concept of a graph coloring problem as a proxy for such coordination problems, which allows us to draw new conclusions and parallels with other problems that require consensus instead of specialization.

One of the classic group decision-making problems is the question of leadership through voting. The outcome of an election is determined by the properties of the underlying electorate, and we use a spatial model of voting to examine polarization and the relationship between rising voter extremism and extremism in the political elite class.

One of the commonly-cited drivers of rising polarization is the recent explosion in misinformation driven by online social media. We examine how fake news spreads through a social network, test the effectiveness of relying on citizen fact-checkers, and measure the effect social network structure has on our fact-checking efforts.

This work demonstrates the utility of using agent-based models when studying social dilemmas and we hope that these techniques will continue to be applied to critical problems of the modern era including public health, climate change, and democracy.