Introducing Competitive Graphical Coordination Games

Brandon Collins

1 Introduction

The world is entering a new era of globalization and centralization. One driving force is the rise of big data. The internet and readily available electronics have made massive-scale data collection possible.

Analyzing big data has seen a surge of research interest. Recently, machine learning has been demonstrating impressive results on a wide variety of big data tasks [1]. Thus large entities such as governments and corporations can leverage big data to make informed decisions. The result is a highly competitive global market as companies can hyper optimize themselves to squeeze revenue as far as possible.

However, this development is sudden and rapid, and concerns about corporate ethics in the information age have already been observed. For example, car manufacturers have been caught holding off recalls on cars with known liabilities because the associated law suits were cheaper then issuing a recall [2]. The overarching concern is that instead of using big data to obtain a new standard of ethics, companies opt to strictly optimize profits instead.

In contrast, society remains made up of many different decision makers all with potentially unique personal objectives. So, in the modern era increasingly large entities are able to hyper optimize without morals, but society remains as a distributed system without well defined goals. This raises questions about what societal outcomes occur in the presence of highly influential and self serving entities.

2 Related Work

Society has long been modeled as a distributed system with game theoretic objectives. That is, everyone makes decisions based on personal objectives given local information.
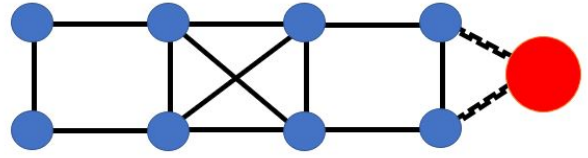

Figure 1: The blue circles denote agents, who play the coordination game with connected agents. The adversary denoted by a red circle influences the network by interacting with select agents.

One prominent societal model is the coordination game [3] which operates on the premise that individuals in society make choices, like which technology standard to use. We call the choices people have *alternatives*. The motivating observation behind coordination games is society benefits when people *coordinate* or choose the same alternative as other people around them. For example, a superior technology standard would be difficult and inefficient for individuals to utilize if a competing standard is dominant.

We formalize this idea via the *graphical coordination game*, where each node is a player and the game is played at every edge as shown in Figure 1. Analyzing graphical models is highly algorithmic, depending on a game theoretic control algorithm called Log Linear Learning [4].

Recently, adversarial variants of this model have seen a surge in the literature [5; 6]. In these models an adversary of various types influences the network to satisfy some objective, also shown in Figure 1. Typically, the adversary manifests itself as fake agents that interact with real agents.

Literature has explored security against adversaries generally in [5] and the importance of information to the adversary in [6]. I explore adversarial outcomes when players are penalized for selecting inferior alternatives in a paper [7] currently under review in the American Controls Conference.

3 Proposal

The ultimate goal of game theoretic models is to model the real world. In turn this allows us to generate real world recommendations from what we observe in the model. I propose to explore graphical coordination games as medium for modeling modern society. Particularly, I seek to model how society interacts with corporate entities. This project will focus on two questions:

1. What are the most effective types of public policy at realizing societal objectives under corporate influence?
2. What societal outcomes occur when society is being influenced by many distinct competing entities?

The adversaries already being explored in literature provide a natural fit for modeling corporations. Existing literature models adversaries of various levels of intelligence, influence, and objectives. This provides a great jumping off point for answering these complex questions surrounding society interacting with modern corporations.

The first question seeks to experiment with different types of policies that impact corporate entities akin to how legislature impacts them. For example, designers could penalize harmful behavior, incentivize charitable behavior, or some combination thereof. To this end, I will analyze the quality of the game-theoretic societal equilibria that arise from allowing the system designer to enforce financial incentives and criminal penalties to provide policy recommendations.

The second question seeks to better model society, which obviously has many influencing entities. A criticism of existing literature is there is little to no work done on multi-adversary coordination games, especially games where adversaries compete. As modeling many competing entities adds a layer of complexity to existing work, my question seeks to lead the way in expanding game theoretic modeling and equilibria analysis to more realistic settings. The goal is to produce models and analysis techniques where questions about society with many influential and competing entities can be asked.

4 Intellectual Merit

This project's intellectual merits are three-fold. Firstly, I will be exploring novel modeling choices. This adds to the body of existing models which will catalyze future work in the field. Secondly, I will produce analytical results on these models which inherently expands the literature surrounding coordination games. Finally, because work on this problem is intrinsically algorithmic, we will produce and study algorithms to better analyze the network.

5 Broader Impact

One of this projects core goals is to inform public policy. Society has seen drastic change in a short period of time given the advent of the internet and related electronic technologies. It is of paramount importance for policy makers to understand how these changes impact the underlying mechanisms of society. My project is a theoretical approach to illuminating the socio-technological landscape for policy makers.

References

[1] Vaswani et al. Attention is all you need. In *Advances in neural information processing systems*, 2017.

[2] Charles Byrns Fleddermann. *Engineering ethics*, volume 4. Prentice Hall Upper Saddle River, NJ, 1999.

[3] H. Peyton Young. The evolution of conventions. *Econometrica*, 61(1):57–84, 1993.

[4] J. Marden and J. Shamma. Revisiting log-linear learning: Asynchrony, completeness and payoff-based implementation. *Games and Economic Behavior*, 75(2):788–808, 2012.

[5] H. Borowski and J. Marden. Understanding the influence of adversaries in distributed systems. In *2015 54th IEEE Conference on Decision and Control (CDC)*, pages 2301–2306. IEEE, 2015.

[6] B. Canty, K. Paarporn, P. Brown, M. Alizadeh, and J. Marden. The impact of complex and informed adversarial behavior in graphical coordination games. *arXiv preprint arXiv:1909.02671*, 2019.

[7] B. Collins and P. Brown. Exploiting an adversary's intentions in graphical coordination games. *submitted to American Controls Conference*, 2019.