Cifre PhD Proposal: "Dynamic learning in Blotto games and applications to modeling attention in social networks"

Supervisors

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Background and work description:

The Colonel Blotto game, proposed by Borel in 1921 [1], is a fundamental model of strategic resource allocation. Two players allocate an exogenously given amount of resources to a fixed number of battlefields with given values. Each battlefield is then won by the player who allocated more resources to it, and each player maximizes the aggregate value of battlefields he wins. This game allows modeling many practical problems of resource allocation in various strategic settings ranging from international war to computer security; it is particularly useful in modeling competition for attention of consumers in social networks.

A simple instance of the Colonel Blotto game was solved in 1950 [4], and only recently, several studies have analyzed the Nash equilibrium of the Colonel Blotto game in more general situations [6, 8], see [7] for a survey. Our recent work also analyzed the solutions of Blotto game on a graph [5]. However, the existing solutions are still unsatisfactory, which limits the possibility of application in particular to competition for attention of consumers in social networks.

The goal of this thesis will be to study several aspects of the Blotto games in order to use it to model competition between advertisers for the attention of consumers in social networks. In this application, battlefields correspond to consumers and their value corresponds to the value of the consumer for the advertiser (typically, the likelihood that the consumer will buy the product). First, we will extend the results on Nash equilibrium in several directions to make them more applicable. In particular, we will extend the model to include more than two players (in order to be

able to model more than two competitors) and to take into account externalities (i.e., the fact that winning a battlefield has an effect on the value of neighboring battlefields in the social network). We will also analyze the performance of heuristics to compute the Nash equilibrium in cases where the exact form is not known. Second, the main part of the thesis will be to analyze the dynamics of the game. In particular, we will study how the advertisers can dynamically learn the value of each consumer in the network by using some variants of the multi-armed bandit problem [2, 3]. This will first require to develop theoretical methods in sequential learning games where several competitors are concurrently performing a learning task whose outcome depend on each other. Those results will permit to develop optimal advertising strategies for the advertisers under competition.

Practical information and application

The PhD is expected to **start early 2016**. Interested candidates should send the following documents to the two supervisors listed above:

- a short statement of interest,
- a detailled CV,
- a list of courses and grades in the last two years (at least),
- the name of 2-3 references willing to provide a recommendation letter for their application.

Applications will be evaluated as they are received and the position will be open until filled, but interested candidates are invited to apply before **November 6, 2015** to ensure full consideration of their application.

References

[1] E. Borel. La théorie du jeu et les équations intégrales à noyau symétrique. *Comptes Rendus de l'Académie des Sciences*, 173(1304–1308):58, 1921.

[2] S. Bubeck and N. Cesa-Bianchi. Regret analysis of stochastic and nonstochastic multi-armed bandit problems. *Foundations and Trends in Machine Learning*, 5(1):1–122, 2012.

[3] J. Gittins, K. Glazebrook, and R. Weber. *Multi-Armed Bandit Allocation Indices*. Wiley, 2011.

[4] O. Gross and R. Wagner. A continuous Colonel Blotto game. *Rand*, 1950.

[5] A. M. Masucci and A. Silva. Strategic resource allocation for competitive influence in social networks. In *Proceedings of Allerton*, 2014.

[6] B. Roberson. The Colonel Blotto game. *Economic Theory*, 29(1):1–24, 2006.

[7] B. Roberson. Allocation games. In J. J. Cochran, L. A. Cox, P. Keskinocak, J. P. Kharoufeh, and J. C. Smith, editors, *Wiley Encyclopedia of Operations Research and Management Science*. John Wiley and Sons, Inc., 2010.

[8] G. Schwartz, P. Loiseau, and S. S. Sastry. The heterogeneous colonel blotto game. In *Proceedings of NetGCooP*, 2014.