Title:

Improving Quantal Cognitive Hierarchy Model Through Iterative Population Learning

Abstract:

In domains where agents interact strategically, game theory is applied widely to predict how agents would act. However, game-theoretic predictions are based on the assumption that agents are fully rational, which unfortunately is not possible when human decision makers are involved. To address this limitation, a number of behavioral game-theoretic models are defined to account for the limited rationality of human decision makers. One popular such model is the "cognitive hierarchy" (CH) model introduced by Camerer et al. (2004), which allows us to explicitly specify different rationality levels for agents in a game. In the CH model, non-strategic agents are regarded as level-0, and their strategies are generated irrespective of other agents (e.g., uniformly randomly or greedily). For strategic agents at level-k (with k greater than 0), they would assume that other agents would be behaving at levels less than k, and compute best responses. The CH model is studied extensively and shown to be an ideal model for capturing strategic human behaviors. Researchers over the years have proposed various ways to further improve the CH model, which are mostly through the improvements in the computations of best responses and level-0 strategies.

In our research, we explore the refinement of the opponent models for strategic agents as the third avenue for improving the CH model. Our proposal is based on the observation that the computation of best responses for level-k agents depends on the normalized belief distribution on opponent's reasoning levels. Once we have best responses at different levels, we can fit them against an agent's decision history to determine each agent's reasoning level distribution, which can then be aggregated to the population reasoning level distribution. As the population reasoning level distribution appears simultaneously as an input and an output, we are essentially seeking it as a fixed point to the above process. By using real-world datasets from the taxi and ride-hailing industries, we demonstrate how our refined CH model and the iterative solution-seeking process can be used in measuring drivers' strategic behaviors. To conclude, we look at how our approach could be generalized to analyze human behaviors in other complex and noisy decision making domains.