Summary for Presentation

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Paper Discussed: On Complexity as Bounded Rationality

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Summary for this paper:

It is proved in this paper that computational methods can be used to solve some paradoxes in game theory. One of the example they provide is that repeated prisoner's dilemma played by finite automata with sub-exponential states can reach an equilibrium with cooperation. They further prove an extended version for the above theorem with the introduction of Pareto points. Finally they present a general model of polynomially computable games, and put them into classes from NP to NEXP. This conclusion actually can be related to authors' landmark contribution of PPAD-class problem.

Discussion in class:

1.Why the parameter c-epsilon was set into that format?

Professor Hari points out that the format of the parameter c-epsilon in fact has something to do with the approximation of exponential function. If we write that into a Taylor expansion form, we can figure out that the author set the parameter in that way in order to an approximate linear function but it is not linear, and it is not as complicated as exponential, therefore that is a sub-exponential. This is very enlightening because it gives us a hint that when dealing with exponential function, a nice approximation is always a good choice if we do not have much knowledge about that.

2.How does the Game Design work?

The second meaningful discussion within the class is about the game design for the proof. Generally speaking, this is a designed game, which means that two players can only play the game in this way. Here the footnote on page 727 helps a lot. It says that collaboration does prevail in the following three other versions of the repeated prisoner's dilemma: the infinite game, the infinite discounted game and the finite repetition with unknown or randomly determined number of rounds. This, combined with the analysis of the rules (since it is a designed game and each player only can play the game in this way), helps us understand the proof.

3.How PPAD come into existence and what does it mean?

The third interesting discussion is about PPAD. PPAD is not a familiar class for us, and it has quite annoying properties. For instance, Nash equilibrium is classified into this question, so we know that there is a solution to this problem but the solution is intractable.

So what is PPAD? PPAD is first defined from PPA theorem. This theorem, the Polynomial Parity Argument says that given a finite graph consisting of lines and cycles (every node has degree at most 2), there is an even number of endpoints.

The class PPAD is defined using directed graphs based on PPA. Formally PPAD is defined by its complete problem: Given an exponential-size directed graph with every node having in-degree and out-degree at most one described by a polynomial-time computable function f(v) that outputs the predecessor and successor of v, and a vertex s with a successor but no predecessors, find a t≠s that either has no successors or no predecessors. Papadimitirou, the author for this paper proves that Nash equilibrium is PPAD-complete.

4.Related works on Machine Learning.

This is the part that I kind of unfinished in class due to limited time. This idea is actually based on two papers, which are 16 years apart. The first paper is by Rubinstein in 1993, which is a paper on Economics. It is assumed in this paper that there is a market with only 1 seller and infinite buyers, and the buyers actually can be divided into two groups, high-cost buyers and low-cost buyers. Here the cost is for sellers, so sellers are more in favor of low-cost. Also, seller knows the 'real value' for the good, while buyers have no knowledge about that. What Rubinstein proves in his paper is that sellers can approach maximum profit as close as possible if high cost buyers can only adapt 'Threshold Strategy', which means high cost buyers are almost excluded by seller's pricing strategy.

Threshold Strategy is like a weak learner, or to be precise, a binary learner. It can only make decision on yes or no. So this problem can be viewed from a machine learning perspective. We can assume that a group of people are a bunch of weak learners. By repeated games between sellers and buyers, can buyers collectively give an accurate inference on the real value of the good? This is actually very close to AdaBoosting, which means that with training and updating weights, an accurate prediction, inference or classification can be made.

The conclusion that Cho and Libgober (2019) come into is that if seller can choose arbitrary pricing strategy and publicize it after choosing, AdaBoosting is PAC learnable; if seller can choose arbitrary pricing strategy but not publicize it after choosing, AdaBoosting is not PAC learnable. So there are some pricing strategies that cheat AdaBoosting algorithm so that they are not PAC learnable. So the next question is what pricing strategies cheat AdaBoosting?

Cho and Libgober give their conclusion in the same paper. They say that if seller only choose the best response pricing strategy against AdaBoosting, even seller does not publicize his strategy, AdaBoosting can also figure out the 'real value'. If we translate this conclusion into a Game Theory term, it says that if seller being rational, and always choose the best response, then he cannot cheat AdaBoosting, but if not being rational, he can cheat AdaBoosting and get a higher profit. So the maximum profit for seller is not from best response, but irrational response, which is kind of connected with the conclusion we come into in this paper, saying that both being rational will lead to a non-Pareto Nash equilibrium, but with irrationality involved, they can come to a better equilibrium.