CFEM workshop: Theory and Practice of Multiparty Computation
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Title: An Epistemic Approach to Mechanism Design

We introduce an epistemic framework for analyzing mechanisms. This framework enables mechanism designers to define desirability of outcomes not only based on players' actual payoff types and their beliefs about the payoff types of other players (as in the classic models), but also based on higher order beliefs of the players (i.e., beliefs about beliefs about ... the payoff types of the players). In this framework, we may also use epistemic solution concepts to analyze what outcomes are consistent with different levels of rationality: a player is k-level rational if he is rational and considers all other players (k-1)-level rational; following Aumann, we consider a very weak notion of rationality: player i is *rational* if he uses a strategy \sigma such that for every alternative strategy \sigma', i considers some world possible where \sigma performs at least as well as \sigma'.

We showcase this framework in the context of single-good auctions, presenting an interim individually-rational mechanism with the following revenue guarantee: for any k\geq 0, any outcome consistent with all players being (k+1)-level rational guarantees the seller a revenue of G^k - \epsilon (for any \epsilon > 0), where G^k is the second highest belief about belief about ... (k times) about the highest valuation of some player. We additionally show that no interim individually rational mechanism can guarantee a revenue of G^k - \epsilon for any constant \epsilon, if only assuming players are k-level rational (as opposed to (k+1)-level rational). Taken together, these results demonstrate the existence of a ``revenue-rationality hierarchy'': strictly higher revenue may be extracted by assuming players satisfy higher levels of rationality.

Towards analyzing our mechanism and proving our lower bounds, we introduce an iterative deletion procedure of dominated strategies that precisely characterizes strategies consistent with k-level rationality. Prior knowledge of mechanism design or epistemic logic will not be assumed.

Joint work with Jing Chen and Silvio Micali.