Anchor games for parallel repetition

Abstract:

Raz’s celebrated Parallel Repetition Theorem shows that the probability of simultaneously winning $n$ independent instances of a two-player one-round game $G$ is exponentially small in $n$, when the maximum success probability of $G$ is less than 1. Though the statement is intuitive, the proof is rather nontrivial and has found important application in hardness of approximation, cryptography, and communication complexity.

There are two major open problems regarding the parallel repetition of games: does an analogue of Raz's theorem hold for (a) games with more than two players, and (b) games with quantumly entangled players? Extending Raz’s theorem to these settings is a challenging problem for a number of reasons: techniques for attacking direct sum/direct product problems in multiparty settings are lacking, and our understanding of quantum entanglement as an information theoretic resource is quite limited.

In this work, we show to sidestep these barriers and make progress on the two open problems. We first prove exponential-decay parallel repetition theorems for a class of games we called “anchored games” in the multiplayer and entangled-player settings. Then, we show how to efficiently transform any game into an equivalent anchored game. Together, our results provide a simple hardness-amplification technique for games in both the classical multiplayer and quantum settings.

Joint work with Mohammad Bavarian and Thomas Vidick.