
NON LOCAL GAMES

Ayush Kumar
IIT Kanpur
Department of Computer Science
{kumayu}@iitk.ac.in

Gurbaaz Singh Nandra
IIT Kanpur
Department of Computer Science
{gurbaaz}@iitk.ac.in

Niket Jain
IIT Kanpur
Department of Computer Science
{nikejain}@iitk.ac.in

1 Context

We first discuss non-local games, which offer a means to understand the phenomenon of non-locality. A non-local game is a cooperative game played by 2 or more players against a referee, where the goal of players is to jointly win the game. The only communication allowed is between the players and the referee, where each player receives a random question from a known distribution and responds with an answer to the referee. Depending on the questions and answers, the referee decides if the players win the game or not.

Now as we recall, in 1964, Bell was able to discard the local hidden variable theories, and the concept of local variables proposed by EPR paradox simply could not explain Quantum Mechanics. Hence, the only way such that the hidden variable could explain the predictions of quantum physics is if they are non-local in some sense, that is the two particles were able to interact instantaneously no matter how widely the two particles are separated. Non-local games become a natural and more intuitive way to understand Bell's inequality and realize the power of entanglement, and that the quantum strategies might outperform classical strategies in the maximum probability of winning a game.

2 Problem

This research paper studies the implications of quantum entanglement to non-local games, which are cooperative games of incomplete information. It presents some examples of non-local games, in which the quantum strategies outperform the classical ones, i.e. they allow the players to win with a higher probability than is possible in the case of classical strategies. The paper also establishes limits on these probabilities with which strategies using the entanglement can win for 2 restricted classes of games: binary games and XOR games. We also study the effect quantum entanglement has on the soundness property of two-prover interactive proof systems.

3 Applications

Other than CHSH games, there are several fascinating non-local games. The most researched games are XOR games, where the overall aim is to XOR the results of every player. Other games include the non-zero-sum, magic square, Bayesian, and conflicting interest games as well as the Kochen-Specker and graph isomorphism games. The non-local correlations produced by local measurements on the shared entangled states are essential for gaining a quantum advantage. Remote players adopting local strategies with any shared classical resources cannot achieve similar correlations. These exercises demonstrate how crucial quantum entanglement is to the processing of information. The problem of how to construct meaningful non-local games should be interesting in scaling applications of entangled resources. This paper makes a significant contribution in listing down some non-local games and showing how the non-local nature of entanglement can be harnessed in a computational task to perform a classically impossible feat.