Quantum Strategies and Local Operations

Gus Gutoski

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This thesis is divided into two parts. In Part I we introduce a new formalism for quantum strategies, which specify the actions of one party in any multi-party interaction involving the exchange multiple quantum messages among the parties. This formalism associates with each strategy a single positive semidefinite operator acting only upon the tensor product of the input and outpu message spaces for the strategy. We establish three fundamental properties of this new representation for quantum strategies and we list several applications, including a quantum version o von Neumann's celebrated 1928 Min-Max Theorem for zero-sum games and an efficient algorithm for computing the value of such a game.
In Part II we establish several properties of a class of quantum operations that can be implemented locally with shared quantum entanglement or classical randomness. In particular, we establish the existence of a ball of local operations with shared randomness lying within the space spanned by the no-signaling operations and centred at the completely noisy channel. The existence of this ball is employed to prove that the weak membership problem for local operations with shared entanglement is strongly NP-hard. We also provide characterizations of local operations in terms of linear functionals that are positive and "completely" positive on a certain cone of Hermitian operators, under a natural notion of complete positivity appropriate to that cone. We end the thesis with a discussion of the properties of no-signaling quantum operations.

Comments: PhD thesis, 149 pages. Chapter 5 is new. Part I (except Chapter 5) is an expanded and revised version of arXiv:quant-ph/0611234. Part II is nearly identical to arXiv:0805.2209
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