N-Player Many-Valued Quantum Games

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Game theory (GT) involves the study of competition and cooperation, without regard to the particular entities (agents) involved, and issues of rationality associated with such phenomena. Researchers have succeeded in implementing many-valued logic gates using many-valued quantum systems. The notion of using quantum computing (QC) in GT has been suggested by various authors. This paper investigates the issues of implementing games' maximin dynamics using new many-valued quantum computing (MVQC) approaches and algorithms.

Quantum computing is a method of computation that uses a dynamic process governed by the Schrodinger Equation (SE), where new physical phenomena such as the quantum parallelism and quantum entanglement emerge. Research in QC gained momentum, for its application within the context of GT, when it has been shown that the Prisoner's Dilemma (PD) game (which is not solvable in a single iteration and can be classically solved in several ways such as (1) iterated games, (2) non-myopic rationality, and (3) meta-games) can be solved using a QC method.

Motivations for pursuing the possibility of implementing (and simulating) game's dynamics using a quantum computer (or quantum circuits) would include items such as: (1) power: the fact that, theoretically, the internal computations in QC systems consume no power, and power is only consumed when reading and writing information into a quantum computer; (2) size: the current trends related to more dense hardware implementations are heading towards 1 Angstrom, at which quantum mechanical effects have to be accounted for; and (3) speed: if the properties of superposition and entanglement of quantum mechanics can be usefully employed in the GT context, significant computational and modeling speed enhancements can be expected.

A main objective of this paper is to introduce MVQC of games' (maximin) dynamics utilizing many-valued quantum bits (qubits). Various types of quantum decision trees (QDTs) are also introduced as quantum representations and modeling for applying MVQC to a games' dynamics. The various MVQC implementation approaches and algorithms that are introduced in this paper can be used for modeling the (maximin) games' dynamics using future low-power consuming quantum circuits and computers.