Optimal Control of Quantum Spin Systems

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ABSTRACT:

Quantum computers have great theoretical promise in applications of vital interest. However, construction of a useful quantum computer is not yet practical and faces many technical challenges, such as the need to prevent quantum decoherence from corrupting the evolution of a quantum spin system. To control an n-qubit system from an initial state to a desired final state amounts to solving an optimal control problem on the Lie group $SU(2^n)$.

For the case of an experimental NMR quantum computer, it has been shown by Khaneja, Brockett and Glaser (2002) that solving this problem is equivalent to finding sub-Riemannian geodesics on a quotient of $SU(2^n)$. However, the methods employed by Khaneja et al do not allow them to solve the problem for $n > 3$ spins.

The research presented here seeks to solve this optimal control problem for higher numbers of spins, using the variational method known as the Griffiths formalism, as well as other methods from differential geometry. The NMR problem is just one example—the methods outlined here can apply to other quantum computing implementations. This paper presents methods and preliminary results.

KEY WORDS: optimal control, quantum control, differential geometry, Lie groups

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