Geometric Control of Quantum Spin Systems

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ABSTRACT:

In 1994 Peter Shor demonstrated that a quantum computer could factor a composite number faster than any known classical algorithm. Since factoring large numbers is crucial to the security of many encryption schemes, this is of vital interest to the Army.

One challenge in building a working quantum computer concerns quantum noise, which can corrupt the desired evolution of a system (a phenomenon called *decoherence*). In the only physical implementation of a quantum computer to date, using nuclear magnetic resonance (NMR), control inputs are mediated by radio-frequency (rf) pulses, and to avoid decoherence it is desirable to make these pulse trains as short and efficient as possible.

Two recent papers by Khaneja, Glaser and Brockett reduced the problem of finding efficient pulse trains for a two-spin or three-spin NMR system to the problem of finding sub-Riemannian geodesics in a quotient space of SU(4). However, the methods they used are not easily scalable to systems with more than three spins. I plan to extend their results to systems with more than three spins using geometric methods from the theory of exterior differential systems, particularly the Griffiths formalism for constrained optimization.

KEYWORDS: quantum control, quantum computing, exterior differential systems, sub-Riemannian geometry.

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