Machine learning Fisher Information Metric from bitstrings

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I. INTRODUCTION

A. Observation

Ideal quantum computers are conjectured to exhibit a quantum speedup in returning samples from low-energy states of H.

II. CAVEATS

A. Quantum speedup in sampling

Consider a Hamiltonian. For example, it can be picked from one of the following families.

- **Lattice Hamiltonian.** A Hamiltonian on a d-dimensional rectangular grid:

$$H = \sum_i (h_i^X X_i + h_i^Z Z_i) + \sum_{\langle i,j\rangle} J_{ij}^{XZ} X_i Z_j + \frac{1}{2}\sum_{\langle i,j\rangle}\Big(J_{ij}^{XX} X_i X_j + J_{ij}^{YY} Y_i Y_j + J_{ij}^{ZZ} Z_i Z_j\Big). \quad (1)$$

  Here $\langle i,j\rangle$ in the sum indicates that the sum is over the pairs of nodes i and j connected by an edge, $J_{ij}^{XX} = J_{ji}^{XX}$, $J_{ij}^{YY} = J_{ji}^{YY}$, $J_{ij}^{ZZ} = J_{ji}^{ZZ}$. We picked specifically the terms X, Z, XX, XZ, YY, ZZ to keep the elements of the Hamiltonian in the computational basis real, which is desireable due to theorem [VK: TODO:ref] below.

- **Hamiltonian on a random graph** A Hamiltonian on a graph (e.g. a MAXCUT Hamiltonian on a 3-regular graph).

While Hamiltonian on a random graph presents a challenge to most of the classical algorithms, the problem of finding the ground state of such Hamiltonian was not studied extensively in the literature.

We define the sampling problem as follows. Let $|\psi_0\rangle$ be the ground state of the Hamiltonian and p be the corresponding probability distribution.

Do quantum computers exhibit a quantum speedup in finding low energy states?

Classically the ground state of 1-dimensional systems can be approximated using DMRG in polynomial time.

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