Optimization using Quantum Mechanics: Quantum annealing through adiabatic evolution

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ABSTRACT

I will briefly review some recent work in the field of quantum annealing, alias adiabatic quantum computation. The idea of quantum annealing is doing optimization by a quantum adiabatic evolution which tracks the ground state of a suitable time-dependent Hamiltonian, where quantum fluctuation are slowly switched off. We illustrate some applications of quantum annealing strategies, starting from textbook toy-models --- double-well potentials and other one-dimensional examples, with and without disorder. These examples display in a clear way the crucial differences between classical and quantum annealing. We then discuss applications of quantum annealing to challenging hard optimization problems, like the Random Ising model, the Traveling Salesman Problem, and Boolean SATISFIABILITY problems. The techniques used to implement quantum annealing are either deterministic Schr\"odinger's evolutions, for the toy models, or path-integral Monte Carlo and Green's function Monte Carlo approaches, for the hard optimization problems. The crucial role played by disorder and the associated non-trivial Landau-Zener tunneling phenomena is discussed.