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Beyond quantum inspired annealing for quadratic unconstrained binary optimization

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Abstract

We have developed a method to extend the functionality of Ising machines such as quantum and digital annealers, which currently have an energy function limited to a binary-quadratic form. The proposed method utilizes auxiliary variables dependent on the decision variables of the problem to be solved so that it can be accelerated by hardware parallel processing. Auxiliary variables add third-order or higher terms or rectified linear unit-type nonlinear functions to the binary-quadratic energy function of Ising machines, modifying the value of the energy difference resulting from the reversal of the decision variable. To enable parallel computation, the computation of the energy change uses information that can be accessed locally by the decision neurons. We confirmed that the proposed method works for the 0/1 linear knapsack problem, the quadratic knapsack problem, the 3-SAT problem, and the random 3-XORST problem.