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Low Rank Non-Negative Matrix Factorization with D-Wave 2000Q

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In this work we want to demonstrate the effectiveness of the new D-Wave quantum annealer, D-Wave 2000Q, in dealing with real world problems. In particular, it is shown how the quantum annealing process is able to find global optima even in the case of problems that do not directly involve binary variables. The problem addressed in this work is the following: taking a matrix V, find two matrices W and H such that the norm between V and the matrix product WH is as small as possible. The work is inspired by O'Malley's article, where the author proposed an algorithm to solve a problem very similar to ours, where however the matrix H was formed by only binary variables. In our case neither of the two matrices W or H is a binary matrix. In particular, the factorization foresees that the matrix W is composed of real numbers between 0 and 1 and that the sum of its rows is equal to 1. The QUBO problem associated with this type of factorization generates a potential composed of many local minima. We show that simple forward-annealing techniques are not sufficient to solve the problem. The new D-Wave 2000Q has introduced new solution refinement techniques, including reverse-annealing. Reverse-annealing allows to explore the configuration space starting from a point chosen by the user, for example a local minimum obtained with a precedent forward-annealing. In this article we propose an algorithm based on the reverse annealing technique (that we called adaptive reverse annealing) able to reach global minimum even in the case of QUBO problems where the classic forward annealing, or uncontrolled reverse annealing, can not reach satisfactory solutions.

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