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Optimize Combination of Recommendation Items by Quantum Annealing Processor

Information recommendation is utilized on many websites, which provides useful information for users. In most information recommendation system, all items are scored independently, and items with a high score are selected, even when multiple items need to be recommended. Since the recommended items should influence each other actually, it seems that the information recommendation in consideration of affinity between items is more desirable for users. However, to find the optimal solution requires a large amount of computation, because the number of combination patterns of items explodes exponentially with the number of items. In our study, we investigated a method to achieve high optimality rapidly by quantum annealing [1,2]. Our problem is to find a combination of recommended items with a specified number so that the specified score function maximizes. The contribution of our study is as follows. First, we devised a framework of introducing constraint equations. Instead of just adding a penalty term representing the constraint of fixing recommendation number, we proposed a term giving a penalty for adopting a recommended item. In other words, a penalty term is introduced as long-ranged interactions in conventional methods, whereas in our proposed method, a penalty term is represented as external fields. Our framework brings out the performance of quantum annealing. Second, we performed the combinatorial optimization problem using quantum annealing hardware, D-Wave 2X. Here we used our framework as mentioned earlier. Using our framework corresponds to searching for penalty coefficients such that a specified number is selected. Thus, we succeeded to improve the combination optimality further and to reduce the required coefficient setting between qubits.

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[1] T. Kadowaki and H. Nishimori, Physical Review E, 58, 5355 (1998).
[2] T. Kadowaki, Ph. D Thesis (Tokyo Institute of Technology, 1999). arXiv:quant-ph/0205020