Solving Maximum Independent Set Problems with a Coherent Ising Machine

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The Maximum Independent Set (MIS) problem is a fundamental optimization challenge in graph theory, with applications in areas such as network design and resource allocation. In this study, we present experimental results demonstrating that a coherent Ising machine (CIM) [1–4] can efficiently identify independent sets in large graphs within a very short time frame [5].

The CIM hardware utilized in our experiments is based on a system featuring 100,000 degenerate optical parametric oscillator (DOPO) pulses, which represent the Ising spins and are coupled through measurement feedback with a 2-bit resolution [6]. For this experiment, we modified the measurement-feedback system to accommodate 50,000 spins with an 8-bit coupling resolution. To map the MIS problem onto the Ising model, we implemented an external magnetic field term, which facilitates interaction between a DOPO pulse representing an Ising spin and additional DOPO pulses that function as external magnetic fields.

For benchmarking purposes, we generated random graphs with a density of 50% and sizes ranging from 500 to 20,000. We evaluated the time-to-solution (TTS) for approximating fair independent sets in these graphs. The target solutions for TTS were based on the best independent set (IS) identified by the CIM, and we compared these results with the TTS obtained using a digital Ising model solver based on optimized simulated annealing (OSA) [7], implemented on a 100-core CPU. The experimental result suggests that, while the TTS for OSA steadily increases with graph size, the TTS for the CIM remains relatively stable. This finding suggests that the CIM possesses a scaling advantage in approximate optimization compared to the OSA implemented on a CPU.

References

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