Usage Report for Fiscal Year 2023

Project Title:

Noise sensitivity of analog combinatorial optimization solvers

Name:

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1. Background and purpose of the project, relationship of the project with other projects

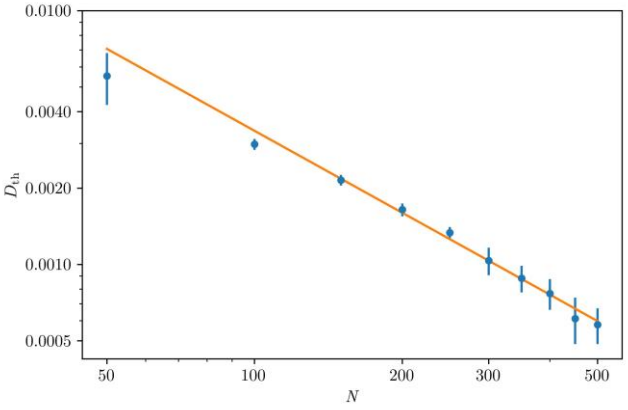
The goal of the project is to analyze the noise sensitivity of deterministic analog combinatorial optimization solving algorithms. To this end, we have been investigating a k-SAT solving algorithm and a solver for the Ising problem. We add artificial noise to the evolution equations and evaluate the impact on the solution-finding capabilities of these algorithms.

2. Specific usage status of the system and calculation method

We have been using the Hokusai system to solve the corresponding high-dimensional sets of stochastic differential equations. Specifically, we scan over large parameter spaces, including problem sizes from N=50 to N=500, randomly chosen initial conditions, and a broad range of noise intensities.

3. Result

We find, and have consolidated, that the Ising solver exhibits characteristic problem size-dependent noise thresholds. Accordingly, if the noise intensity is below the threshold, then the solution finding-capability remains high, whereas the latter rapidly drops to zero when the noise threshold is exceeded. Importantly, we find that these noise thresholds D_{th} scale (inversely) polynomially with the problem size, i.e., the larger the problem size, the smaller is the noise threshold.



Scrutinizing the noise impact on the k-SAT solver, we have found evidence of two noise thresholds: an early threshold that filters only hard problems, and a subsequent threshold that applies to all problem instances.

4. Conclusion

We have discovered clear and regular patterns in the noise responses of these combinatorial optimization solvers. These thresholds allow users to predict and extrapolate the problem sizes beyond which, given constant noise levels, the analog combinatorial optimization solvers fail to find correct solutions.

5. Schedule and prospect for the future

The data accumulation has basically been completed. We are currently in the process of writing a manuscript that summarizes our results.

6. If no job was executed, specify the reason.