Amoeba-inspired Nanoarchitectonic Computing for Solving Computationally Demanding Problems

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Abstract: Biologically inspired computing architectures are expected to overcome the limitations of conventional technologies in terms of solving computationally demanding problems, reducing energy consumption, and so on. We demonstrated that a single-celled amoeboid organism (a plasmodial slime mold P. polycephalum), which exhibits complex spatiotemporal oscillatory dynamics and efficient decision-making capabilities, can be used to search for a solution to a very hard combinatorial optimization problem (Fig.1) [1].

Aono modeled the spatiotemporal dynamics by which the amoeba searches for the solution and showed that the model, called "AmoebaSAT," can be implemented by various nanophotonic and nanoelectronic systems that exhibit suitable stimulus response and spatiotemporal dynamics resembling the behavior of the amoeba [2,3].

In fact, photoexcitation transfer phenomena in quantum dots (QDs) generate the amoebalike spatiotemporal dynamics and can be used to solve the Satisfiability problem (SAT), which is the problem of judging whether a given logical proposition is self-consistent (Fig. 2) [4]. SAT is an NP-complete problem that is believed to become intractable for conventional digital computers when the problem size increases, and fast SAT solvers are useful for diverse.

AmoebaSAT is several orders of magnitude faster than the fastest-known stochastic local search algorithm for randomly generated 3-SAT instances. These results indicate the potential for developing highly versatile nanoarchitectonic computers that realize powerful computing with low energy consumption.

References

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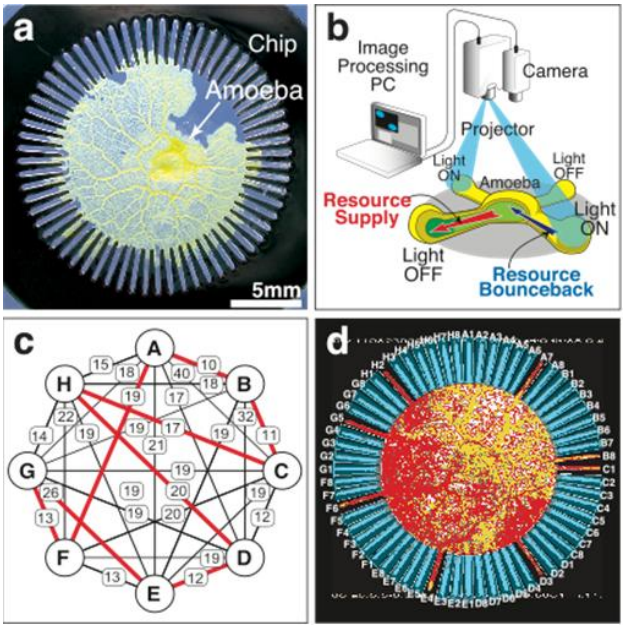

Figure 1. Amoeba-based computer for solving the 8-city traveling salesman problem.

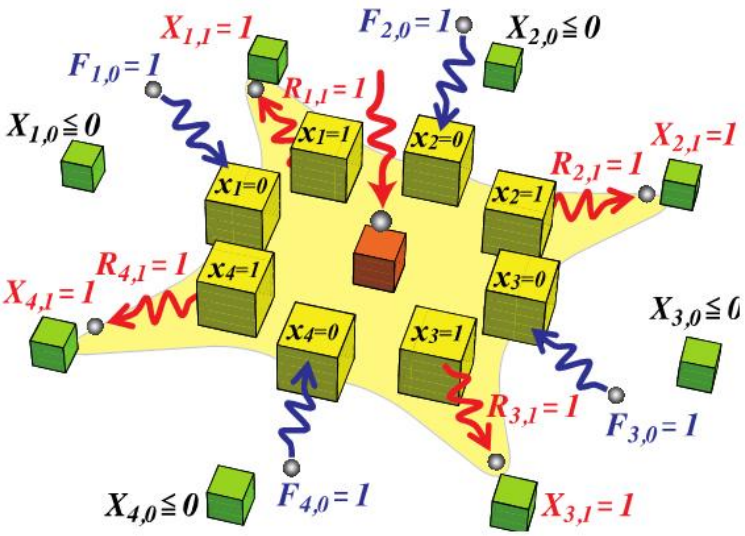

Figure 2. Amoeba-inspired nanophotonic computer for solving the 4-variable satisfiability problem