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PARALLEL EXECUTION OF NEURAL NETWORKS WITH MIXED BIASES FOR SOLVING SATISFIABILITY PROBLEM

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Abstract. *We have proposed a neural network called LPPH (Lagrange Programming neural network with Polarized High-order connections), for solving the SAT (SATisfiability problem), together with a parallel execution of LPPHs to achieve a high speedup ratio. LPPH dynamics has an important parameter called attenuation coefficient which strongly affects execution speed. For the parallel execution, it is important to increase diversity of the set of LPPHs. We have proposed a method in which LPPHs have mutually different attenuation coefficients generated by a probabilistic generating function. We also proposed LPPH dynamics with bias terms which put bias to variables. These are several kinds of biases, e.g., a bias toward 1 (positive bias), a bias toward 0 (negative bias), and a bias toward 0.5 (centripetal bias). For some problems, the positive bias has an advantage if percentage of 1s is high in solutions, and the negative bias if percentage of 0s is high. However the execution speed of LPPH dynamics does not completely depend on percentages of 1s or 0s. In this paper, to overcome this difficulty and increase the diversity, we propose a parallel execution in which the above biases are mixed, Experimental results show effectiveness of this method.*
Keywords: Parallel execution, Neural network, SAT, Lagrangian method

1. **Introduction.** The SAT (SATisfiability problem) belongs to a class of CSP (constraint satisfaction problem), which is an important class of basic problems in wide fields of computer science and practical applications, such as decision making, scheduling, and designing, etc. The SAT is a famous NP-complete problem which in general requires a lot of time to solve as the problem size becomes large. For the SAT, we proposed a recurrent analog neural network, called Lagrange Programming neural network with Polarized High-order connections (LPPH) [1], which is based on the Lagrangian method and has the following properties: (1) Solutions of SAT are equilibrium points of LPPH and vice versa. (2) When a trajectory of LPPH passes near a solution of SAT, it converges to the solution.

When a neural network is simulated by software, usually parallel processing is done by, first dividing networks into parts, then executing each part on a different computer individually. Much research of this type of parallel processing has been done, see for example, [2-4]. However this type of parallel processing requires high communication overhead, and a high speedup ratio cannot be achieved generally.