International Journal of Innovative Computing, Information and Control
Volume **5**, Number **6**, June **2009**

ICIC International ©2009 ISSN 1349-4198
pp. 1569–1586

TRANSIENTLY CHAOTIC NEURAL NETWORK BASED ON SWITCHED COOLING AND ITS APPLICATION TO MAXIMUM CLIQUE PROBLEM

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Received May 2008; revised October 2008

Abstract. *In this paper we propose a new transiently chaotic neural network model based on switched cooling (TCNNSC) for combinatorial optimization problems, which can escape from local minima and has powerful ability to search the globally optimal or near-optimum solution. By introducing the switched cooling mechanism into transiently chaotic neural network, the control granularity becomes small to decide when to terminate the chaotic dynamics, and how to make use of chaotic behavior for convergence to a stable equilibrium point corresponding to an acceptably near-optimal state. A significant property of the new model is that chaotic dynamics can be increased transiently when chaotic searching conditions are satisfied; otherwise chaotic dynamics is decreased quickly to accelerate the convergent process. Therefore the proposed model can be expected to have higher ability to escape from local minima and to search for globally optimal or near-optimal solutions. In addition, since chaotic dynamics can be increased and decreased under the control of the switched cooling mechanism, the searching space of the proposed model for optimization is further reduced. For the reduced search spaces and the accelerating convergent process, the network could use less CPU time to reach a saturated state. A large number of instances on the maximum clique problems have been simulated to verify the proposed model.*
Keywords: Neural network, Transiently chaotic neural network, Annealing strategy, Maximum clique problem

1. **Introduction.** Neural network has been shown to be a powerful tool for solving combinatorial optimization problems. One of the typical models of artificial neural networks is the Hopfield neural networks with symmetric connection weights [1, 2, 3], which is widely used in solving combinatorial optimization problems. Because of their gradient descent dynamics, the Hopfield neural networks guarantee convergence to a stable equilibrium point. However, it causes severe local-minimum problems whenever it is used for solving combinatorial optimization problems. Although many methods have been presented to improve the Hopfield neural networks [4, 5, 6], the results are not always satisfactory.

At present, many neural network methods have been proposed to solve combinatorial optimization problems [7]. In 1993, Yamada et al. proposed an energy decent optimization algorithm called RaCLIQUE for optimization problems [8]. They compared the performance with the simulated annealing, NMCLIQ and the exact algorithm. The simulation results showed that the solution quality of RaCLIQUE was close to the exact algorithm and better than other approximation algorithms, but the computation time was comparable. In 1995, Jagota proposed five energy-decscent optimization algorithms using the Hopfield neural network for approximating the maximum clique problem [9]. Five