Dynamic Characteristics of Neuron Models and Microchip Integration

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There have been many researches of various neuron models which typically take the form of ordinary nonlinear differential equations of several dimensions. The pattern of spiking is of great importance, because it is believed that it codifies the information transmitted by neurons. The neural networks comprising the interconnection of the neuron units are actively studied problems in the field of nonlinear dynamics and the brain research. It is an urgent problem to apply various neuron models to the networks that aim at intelligent information processing. One of important aspects of this situation is the lack of universal discussion over the dynamical behaviors of various neuron models. Hence we reveal that each model has the potential function and the active areas on the potential. This common concept realizes the universal discussion of the dynamical behaviors, for example, bursting, spiking, etc. On the other hand, a Hopfield neural network can converge on a solution of combinatorial optimization problems and it has parallel and high speed operation. However, local minima in the final states present serious problems. The negative resistance of a neuron model can make the network state free from the problem by selective destabilization of local minima. Thus we expect that it has a potential to overcome the local minimum problems. In computer simulation and theoretical estimation, we have already shown that the ID network, which we presented for simulation of an active artificial neural network to implement associative memory and combinatorial optimization problems, can be free from local minima and that it converges on the optimal solutions only. The prototype chip for the burst ID model, which shows bursting dynamics as an extended version of the ID model, has been implemented and measured.

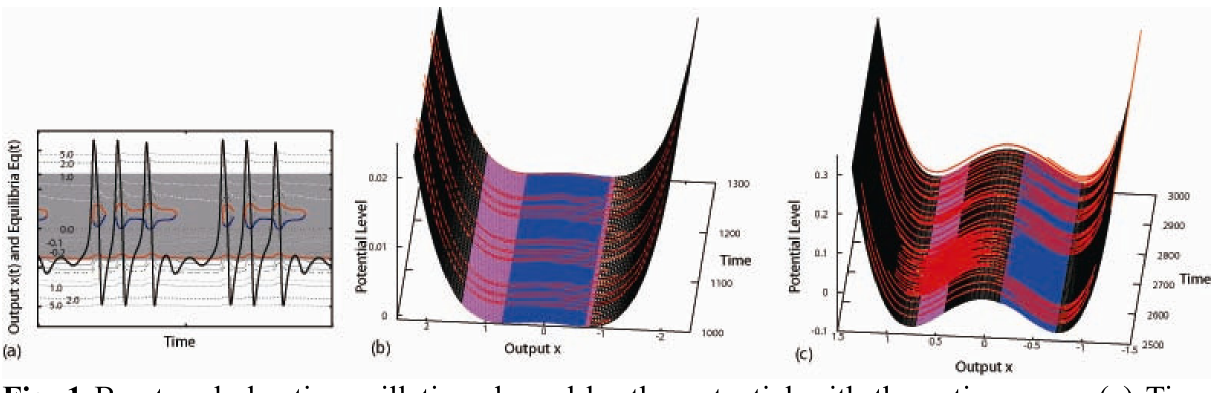

Fig. 1 Burst and chaotic oscillations bound by the potential with the active areas. (a) Time series of output on a contour map of the potential. (b) and (c) Bird's eye views of outputs on the potentials.

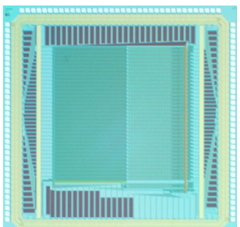

Fig. 2 Photograph of a microchip for the Burst ID artificial neural network