Dynamic Characteristics of Neuron Models
and
Microchip Integration of Active Neural Networks

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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. It is an actively studied problem to apply various neuron models to artificial neural networks (ANNs) for intelligent information processing in the field of nonlinear dynamics and the brain research.

One of important aspects of this situation is the lack of universal discussion over the dynamical behaviors of various neuron models, though perturbation and bifurcation theories exist. Thus we reveal that each model has its own potential function and active areas on the potential. Negative resistance is one of active areas. This concept realizes the universal discussion of the dynamical behaviors of models, for example, bursting, spiking, etc.

On the other hand, Hopfield neural network is capable of solving combinatorial optimization problems and it is a parallel-processing version of the gradient method. However, it has some drawbacks. One of the most concerning drawbacks is that it frequently finds locally minimum solutions instead of global minima.

The active areas of neuron models make the state of network escape from local minima by their destabilization. In computer simulation and theoretical estimation, we have already shown that the ID network, which is one of active ANNs to implement associative memory and combinatorial optimization problems, is capable of converging on optimal solutions only.

The prototype chip of a burst ID model, which shows bursting dynamics as an extended version of the ID model, has been fabricated and measured.

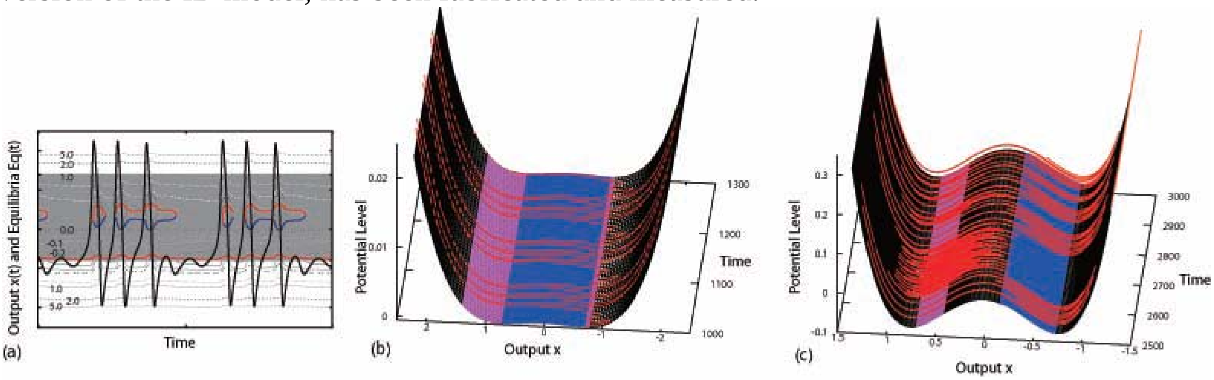

Fig. 1 Burst and chaotic oscillations bound by the potential with the active areas. (a) Time series of output on a contour map of the potential. Bird's eye views of outputs on the potentials, (b) for a burst oscillation and (c) for a chaotic oscillation.

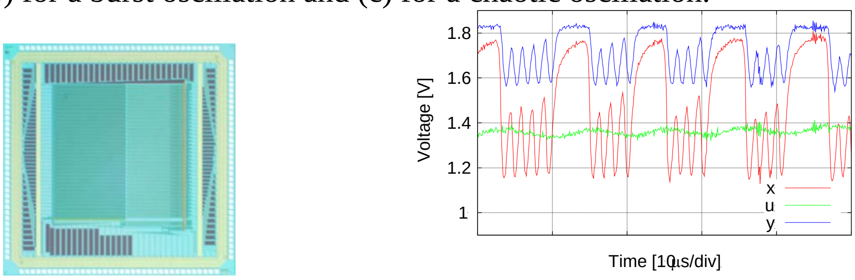

Fig. 2 Photograph of a microchip for the Burst-ID ANN, and an observed bursting output.