Kyoto Dynamics Days 6

# Dynamics of Coupled Systems

March 6 - 7, 2006

Department of Mathematics, Kyoto University
Large Meeting Room in Math. Department Bldg.

## Program

March 6

11:00-11:45

Chih-Wen Shih (National Ciao-Tung University, Taiwan)

Lecture 1: Introduction to Artificial Neural Networks

Abstract: I will introduce the equations of Hopfield neural networks, celllular neural networks, and their applications. These models are represented by continuous-time dynamical systems in the forms of ordinary differential equations and delayed equations. Recently there are also certain extensions to discrete-time systems. I will address the dynamical properties of these equations as well as their connections to the applications.

Lunch

1:30-2:30

Motomasa Komuro (Teikyo University of Science and Technology)

Title: Generic structure of stable parameter regions and chaotic itinerancies in globally coupled systems.

Abstract: I will introduce a generic structure of parameter regions for stable periodic orbits in globally coupled systems. One-dimensional logistic maps, two-dimensional Henon maps, and three-dimensional Rossler differential equations are used as the basis dynamical system of coupled systems. Also, I will state a structure of crisis parameter regions and a mechanism of chaotic itinerancies in globally coupled systems.

2:45-3:30

Chih-Wen Shih (National Ciao-Tung University, Taiwan)

Lecture 2: Monostability and Multistability in Hopfield Neural Networks

Abstract. The applications of neural networks range from classifications, associative memory, image processing, and pattern recognition to parallel computation and its ability in solving optimization problems. The theory on the dynamics of the networks has been developed according to the purposes of the applications. In the application to parallel computation and signal processing involving finding the solution of an optimization problem, the existence of a computable solution for all possible initial states is the best situation. Mathematically, this means that the network needs to have a unique equilibrium which is globally attractive. Such a convergent behavior is referred to as ``monostability" of a network. On the other hand, stable stationary solutions correspond to memory capacity in the application of associative memory or pattern recognition for neural networks. In this situation, existence of many equilibria is a necessary feature. The notion of ``multistability" of a neural network is used to describe coexistence of multiple stable patterns such as equilibria or periodic orbits. In general, if the dynamics for a system are bounded, the existence of multiple stable patterns is accompanied with coexistence of stable and unstable equilibria or periodic orbits. The existence of unstable equilibrium is essential in certain applications of neural network. For example, unstable equilibrium is related to digital constraints on selection in winner-take-all problems.

We present the existence of multiple stable stationary solutions for Hopfield-type neural networks with delay and without delay. Basins of attraction for these stationary solutions are also estimated. Such a scenario of dynamics is established through formulating parameter conditions based on a geometrical setting.

4:00-5:00

Satoru Tadokoro (Hokkaido University)

Title: Intermittencies and Chaotic Itinerancies in Gap Junction-Coupled Class I* Neurons

Abstract: We have proposed a dynamical model for gap junction-coupled networks of class I* neurons, and investigated its dynamic characters. We found various dynamic states and transitory behaviors among them in a model neural network with diffusively coupled class I* neuron models. Among others, two transitory behaviors, which can be interpreted as chaotic itinerancies, attracted attention in relation with real brain dynamics. One consists transitions between a ruin of an attractor which exhibits in-out intermittency and strong chaos. The other consists transitions between a ruin of an attractor which exhibits on-off intermittency and strong chaos. We investigated structures and mechanisms of these chaotic itinerancies and their relating attractors.

6:00- Dinner

March 7

10:15-11:00

Chih-Wen Shih (National Ciao-Tung University, Taiwan)

Lecture 3: Multistability and Monotonicity in Recurrent Neural Networks

Abstract. We present the existence of $2^n$ stable stationary solutions for a general $n$-dimensional delayed neural networks with several classes of activation functions. The theory is obtained through formulating parameter conditions based on a geometrical setting. Positively invariant regions for the flows generated by the system and the basins of attraction for these stationary solutions are established. The theory is also extended to the existence of $2^n$ limit cycles for the $n$-dimensional delayed neural networks with time-periodic inputs. It is further confirmed that quasiconvergence is generic for the networks through justifying the strongly order preserving property as the self-feedback time lags are small for the neurons with negative self-connection weights. Our theory on existence of multiple equilibria is then incorporated into this quasiconvergence for the network. We also demonstrate the dynamical distinction between different types of activation functions for the networks.

11:30-12:30

Tsuyoshi Chawanya (Osaka University)

Title: Macroscopic dynamics in globally coupled piecewise-linear map systems, relation between finite size systems and "thermo dynamic" limit

Abstract: In this talk, I will introduce an approach to macroscopic dynamics of globally coupled piecewise-linear 1-dimensional maps using a dynamical system corresponding to "thermodynamic" limit. In some part of parameter space, the limiting model has attracing set qualitatively different from that of finite dimensional systems. Numerical results in such parameter area exhibiting a kind of non-stationary behavior will be presented.