

Collaborative Research Center for Innovative Mathematical Modelling

[Innovative Mathematical Modelling for Solving Complex Problems]

Institute of Industrial Science

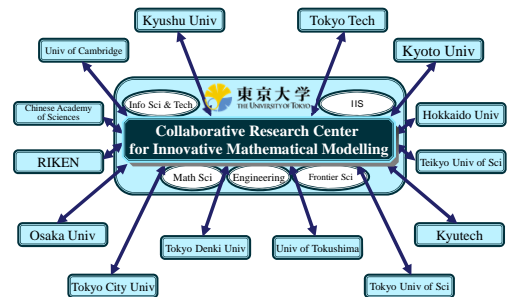
<http://www.sat.t.u-tokyo.ac.jp/center/>

Complex Systems Modelling

Innovative Mathematical Modelling

Mathematical modelling is a way to describe a system of phenomena using mathematical language. We are studying mathematical theory for innovative mathematical modelling and its applications in order to resolve complex issues in science and technology.

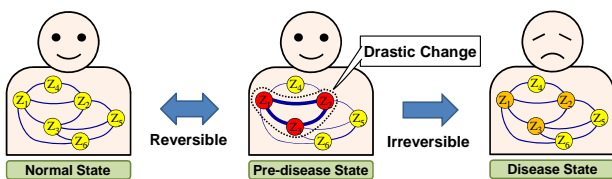
We are promoting the project “Mathematical Theory for Modelling Complex Systems and Its Transdisciplinary Applications in Science and Technology” (Core-Researcher: Kazuyuki AIHARA), which is supported by Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program).



Project Organization Chart

Early Detection of Complex Diseases by Dynamical Network Biomarkers

A biomarker is a substance used as an indicator for distinguish diseased from normal patients. In contrast, we theoretically derive an index based on a dynamical network biomarker (DNB) that serves as an early-warning signal to distinguish pre-diseased from normal patients.



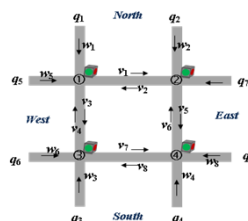
Mathematical modeling of disease progression and DNB

Modeling and Control of Traffic in Urban Road Networks

Traffic on urban road networks exhibits complex behavior due to divers interactions among vehicles and traffic lights, and characteristics of drivers. Traffic congestion can be relieved by efficient driving of vehicles and predictive control of all lights in a network, simultaneously, considering traffic dynamics and conditions in the network.



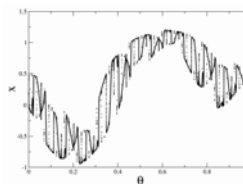
A complex system



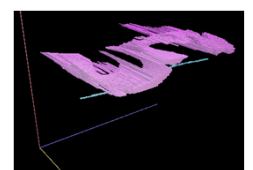
Modeling and control of traffic lights

Transition to Chaos in Quasiperiodically Forced Systems

We investigate transitions from ordered to chaotic states in quasiperiodically forced dynamical systems using bifurcation theory and Conley-Morse graph, which is a graph-based computational representation for global analysis of dynamical systems.



Stable invariant set of a dynamical system (strange nonchaotic attractor)



Stable and unstable invariant sets (Morse sets)

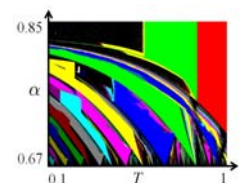
Optically Coupled Oscillators

~ Sync + Bifur = Rhythm of Light ~

An LED firefly is a square-wave oscillator controlled by LED light. A group of LED fireflies forms an Optically Coupled Oscillator (OCO), and OCOs generate a huge variety of synchronous patterns.



LED firefly and optically coupled oscillators



Bifurcation Diagram