ABSTRACTS

March 10 (Mon)　３月10日（月）

Speaker: Alan Champneys (U Bristol, UK)
Title: The dynamics of valve rattle

Abstract: A simple autonomous system of three equations with a square root nonlinearity and an impact is derived as a model of a spring-loaded pressure fluid valve. The system is shown to undergo a rich dynamics, associated with a Hopf bifurcation, two different kinds of grazing bifurcations and chatter-dynamics that seems to provide a non-smooth version of the Shil'nikov mechanism. Comparison with experimental data shows that a second mode of instability can arise if pressure waves within the inlet pipe are taken into account. An improved model is derived, which can be reduced to a system of five ODEs. A thorough two-parameter analysis of this system reveals yet richer dynamics involving complex interplay between two different kinds of periodic motion. It is argued that this system shows how novel questions in dynamical systems can arise from studying industrially-motivated problems. The work presented is joint with Csaba Hos and his colleagues from the Technical University of Budapest.

Speaker: Shinya Aoi (Department of Aeronautics and Astronautics, Kyoto U)
青井伸也（京都大学・工学研究科）
Title: Locomotion dynamics and control in humans and animals

Abstract: Humans and animals produce adaptive locomotion in diverse environments by cooperatively and skillfully manipulating their complicated and redundant musculoskeletal systems. To reveal the underlying mechanism, we conducted (1) analysis of measured data during locomotion to find characteristic structures embedded in locomotion dynamics and control system, (2) simulation study using neuromusculoskeletal models to clarify the functional roles of the embedded structures, and (3) analysis of simple physical model to find essential dynamical structure.

Speaker: Ippei Obayashi (Department of Mathematics, Kyoto U)
大林一平（京都大学・理学研究科）
Title: Construction of the basin of attraction for simple bipedal walking models by the hyperbolicity of inverted pendulum

Abstract: I will talk about the stability of the simple bipedal walking models. Especially, we will focus on the geometric characteristics of the basin of attraction. The basin of attraction is very thin, and have complex structures like slits or stripe patterns. The models are typical hybrid dynamical systems and based on an inverted pendulum. I will show that these two facts play important roles to construct the geometric characteristics of the basin of attraction. In this talk, we focus on the specific model called the simplest walking model, but the result is applicable to other bipedal walking models.

Speaker: Kazuyuki Yagasaki (Department of Mathematics, Hiroshima U)
矢ヶ崎一幸（広島大学・理学研究科）
Title: Melnikov Processes and Chaos in Randomly Perturbed Dynamical Systems

Abstract: We consider a wide class of randomly perturbed systems subjected to stationary Gaussian processes and show that chaotic orbits exist almost surely, no matter how small the random forcing terms are. This result is very contrast to the deterministic forcing case, in which chaotic orbits exist only if the influence of the forcing terms overcomes that of the other terms in the perturbations. To obtain the result, we extend Melnikov's method and prove that the corresponding Melnikov functions, which we call the Melnikov processes, have infi nitely many zeros, so that infinitely many transverse homoclinic orbits exist. In addition, a stable and unstable manifold theorem is given and the Smale-Birkhoff homoclinic theorem is extended in appropriate forms for randomly perturbed systems. We illustrate our theory for the randomly perturbed Duffing oscillator subjected to the Ornstein-Uhlenbeck process.

March 11 (Tue)　３月11日（火）

Speaker: Alan Champneys (U Bristol, UK)
Title: Bifurcations in a dynamic auto-balancer for unstable rotors

Abstract: This is a second talk that presents novel concepts in dynamical systems that arise from an industrially-motivated problem. Engineering dynamics is dominated by linear analysis of vibration and acoustics. However it is increasing realised by engineers that nonlinearity plays a crucial role whenever there is contact or friction. Another important arena for nonlinear dynamics is rotordynamics which forms the basis of just about every power generation, propulsion and machine-tool system. Due to the high rotation speeds, geometric nonlinearity occurs whenever there is a coupling between motions in different reference frames. This talk specifically considers a device that was first proposed almost 100 years ago to balance an eccentric rotor, namely an axially mounted concentric ball race that will automatically respond to centrifugal forces to balance the rotor. The device is rarely used though because as well as balancing the rotor it can also lead to gross forms of instability. An overview is presented of work with collaborators over a number of years that encompasses equivariant bifurcation theory, mixed-mode oscillations, chaotic dynamics and instability prediction in non-normal systems via computation of psuedospectra. The talk ends with some philosophical points about finding interesting mathematics by studying applications - how it is possible to "have your cake and eat it!".

Speaker: Katsutoshi Shinohara (FIRST Aihara Project, JST, U Tokyo)
篠原克寿（FIRST合原プロジェクト, JST, 東京大学）
Title: Beta Encoder: Mathematical Analysis of its Robustness

Abstract: Beta expansion is a method of the expansion of real numbers with radix ¥beta which is not necessarily an integer. Beta encoder is an A/D (Analog-to-Digital) converter based on beta expansions. It has been proposed as a new architecture which exhibits robustness against large process variation and wide spread environment change. In this talk, we explain the implementations of beta encoders done in our project, report its performance and introduce theoretical results which guarantee the accuracy of beta encoders. This research is supported by the Aihara Project, the FIRST program from JSPS, initiated by CSTP.
(joint work with Takaki Makino, Yukiko Iwata, Yutaka Jitsumatsu, Masao Hotta, Hao San and Kazuyuki Aihara)

Speaker: Kasuyuki Aihara (Institute of Industrial Science, U Tokyo)
合原一幸（東京大学・生産技術研究所）

Title: Applications of Dynamical Systems Theory to Personalized Medicine

Abstract: In this talk, I review our research on applications of dynamical systems theory to personalized medicine. First, we formulate hybrid dynamical systems models for prostate cancer and apply them to personalized diagnosis, therapy, and prognosis(1-10). Second, we extend the concept of the conventional biomarkers to that of new dynamical networks biomarkers that can detect early-warning signals for sudden deterioration of complex diseases, or the bifurcation in a personalized way(11-15).

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Speaker: Yoshihiko Susuki (Department of Electrical Engineering, Kyoto University)
薄良彦（京都大学・工学研究科）
Title: Applied Nonlinear Dynamics in Energy Systems Technology

Abstract: Energy systems have attracted a lot of interest in science and technology. In this talk, I will outline our efforts to develop methodology and tools for analysis and design of energy systems. The target systems range from nationwide infrastructure, through regional community, to finally building. First, we will see examples of nonlinear dynamics emerging in industrial problems on energy systems, which require a new theory of dynamical systems bridging between observational data and mathematics. Then, as one example of the bridging theory, we will present stability assessment of nationwide power grids by computing spectrum of the Koopman operator from data on power flow. Also, we will present design and analysis of physical dynamics emerging in regional management of heat and power, which shows how dynamical systems tools are applied to the design issue. Throughout this talk, I will seek a new direction of dynamical systems theory for solving industrial problems on energy systems technology.

Speaker: James Wright (U Surrey, UK)
Title: The effects of time dependent dissipation on basins of attraction

Abstract: In real world systems it is unlikely the coefficient of dissipation will be a periodic function of time or constant throughout the entire time evolution of the system. Despite this, previously when calculating the basins of attraction for a system, only these two cases have been considered. Using numerical simulations, progress has been made to determine how basins of attraction change when dissipation is initially non constant in a system. Some results and expectations will be presented.

Speaker: Tomoyuki Miyaji (Research Institute of Mathematical Sciences, Kyoto U)
宮路智行（京都大学・数理解析研究所）
Title: Computer-assisted analysis on four-leaf orbits of Craik's 3D dynamical system

Abstract: We study three-dimensional dynamical systems defined by ordinary differential equations with quadratic nonlinearity which are similar to Euler's equations of motion for freely rotating rigid body but have linear terms. Unlike Euler's equations, the system admits unbounded solution orbits. We can, however, observe characteristic behavior. Craik and Okamoto have found a "four-leaf" structure, which plays an important role in controlling the solution orbits. We prove the existence and bifurcation of a four-leaf periodic orbit by a method of numerical verification.

Speaker: Mike Jeffrey (U Bristol)
Title: Nonsmooth dynamics: the first 500 years

Abstract: In the first of two talks I shall introduce the principle ideas of nonsmooth dynamics: how switching in a differential equation induces saltation and sticking, and how

these have led to a fast growing theory of discontinuity-induced bifurcations and chaos. I will touch on the many applications, such as electronic relays, power control, biological life cycles, superconductors, and classical mechanics. And all that we have learned will provide a new perspective on dynamical systems theory itself, a story stretching back 500 years, to a fundamental nonsmooth system whose mysteries remain to this day.

March 12 (Wed)　３月12日（水）

Speaker:　Mike Jeffrey (U Bristol)

Title: New horizons in piecewise-smooth dynamics

Abstract: After the first talk, all seems well with the new theory of piecewise-smooth dynamical systems. But a little perspective reveals an undiscovered world of behaviour, and brings our 500 year story full circle. The crucial question is how we model a discontinuity, and the consequences for determinism. Answering these leads to two new concepts: nonlinearity in the switch and determinacy-breaking events. Seemingly deterministic systems become unpredictable, creating new kinds of chaos, but also providing new ways to model complex real-world systems. We hope, finally, that these new phenomena allow us to understand how nonsmooth dynamics is related to singular perturbations.

Speaker: Wen-Guei Hu (National Chiao Tung U, Taiwan)

Title: Pattern generation problems arising in multiplicative integer systems

Abstract: In this talk, I would like to address multiplicative integer systems by using a method that was developed for studying pattern generation problems. The entropy and the Minkowski dimensions of general multiplicative systems can thus be computed. A multi-dimensional decoupled system is investigated in three main steps. (I) Identify the admissible lattices of the system; (II) compute the density of copies of admissible lattices of the same length, and (III) compute the number of admissible patterns on the admissible lattices. Furthermore, a coupled system can be decoupled by removing the multiplicative relation set and then performing procedures similar to the decoupled system.

Speaker:　Toshiyuki Ogawa (Graduate School of Advanced Math. Sci., Meiji U)
小川知之（明治大学・先端数理科学研究科）

Title:　Instability of periodic traveling wave solutions to excitable RD systems

Abstract:　We introduce an excitable RD system to imitate cardiac cell activities and observe the stabilities of periodic traveling wave solutions. There are two families of wave trains, fast and slow. The fast family is basically stable in the case of FitzHugh-Nagumo system. However, we can observe that the fast wave train becomes unstable to form an

oscillatory wave. We shall explain this phenomena by calculating the essential spectrum numerically.

Speaker: Thomas Wanner (George Mason U, USA)
Title: Stochastic Dynamics of Droplet Formation

Abstract: Stochastic partial differential equations serve as basic models for phase separation phenomena in multi-component metal alloys. During a process called nucleation, the additive noise in the system forces the formation of localized droplets which consist of one or more components of the alloy. In this talk, I will discuss dynamical aspects of this behavior through the equilibrium structure of the underlying deterministic model. This will show that even highly unstable equilibria can be observed during nucleation, and in fact serve as organizing centers for the dynamics. I will also try to shed some light on the size of the generated droplets by considering binary systems perturbed by degenerate noise.

Speaker: Kaiichiro Ota (Dept. Applied Analysis and Complex Dynam. Systems, Kyoto U)
太田絵一郎（京都大学・情報学研究科）
Title: Analyzing rhythmic data using dynamical systems theory and Bayesian statistics

Abstract: We propose a Bayesian statistical method for analyzing rhythmic time-series data observed in coupled limit-cycle oscillators. Our method is based on the phase model that is supported by the phase reduction theory. This theory guarantees that the phase model can quantitatively describe the dynamics of the system, if the oscillators are weakly coupled. Our method can reliably obtain the phase model that fits experimentally observed time-series data well, and thus provides a useful tool for analyzing the dynamics of real-world rhythmic systems. We demonstrate that our method works well using numerical simulations. Application to human locomotion experiments is also discussed.

Speaker: Takaaki Aoki (Faculty of Education, Kagawa U)
青木高明（香川大学教育学部）
Title: Organization of complex networks as a dynamical system

Abstract: Large-scale, complexly structured, conglomerations of interactions in real-world systems are often referred as `Network'. Such a network is a contemporary interdisciplinary subject across mathematics, physics, biology, engineering and social science. Although numerous studies have analyzed the networks as static graphs, in fact, the real-world networks are continuously reorganized in response to the changes in our society. To understand their dynamics, we need to consider the co-evolving network dynamics, in which the reformation of the networks and the dynamical processes occurring on them are closely interdependent. We introduced a simple model, by combining the dynamics of random walkers on a weighted network and the dynamics of the link weights driven by resource that the walkers carry. As a result, we found unsteady microscopic dynamic state of the network with stationary power-law distributions of the resource and

the link weights. Moreover, the Lyapunov analysis revealed that the system has multi stability including chaotic states.

Speaker: Tomas Gedeon (Montana State University, USA)
Title: State space reconstruction and causal inference

Abstract: It has been long recognized that correlation between two random variables does not imply causation. The alternative framework of Granger causality (GC) uses predictability to identify causation, but is limited by an assumption of separability of two random variables. Recently, a method, dubbed Convergent Cross Mappings (CCM), has been developed to detect causal relationships based on the state space reconstruction of time series data. While GC is designed for stochastic processes, CCM applies to weakly or moderately coupled variables in systems where deterministic dynamics plays a dominating role.

In our contribution we refine CCM method and develop a precise mathematical theory, which puts CCM on solid mathematical framework. This allows us to illuminate strengths and limitations of CCM in both theory and practice.

<u>March 13 (Thr)　３月13日（木）</u>
Speaker: Thomas Wanner (George Mason U, USA)
Title: Multistability in the Diblock Copolymer Model

Abstract: The diblock copolymer equation models phase separation processes which involve long-range interactions, and therefore promote the formation of fine structure. From a mathematical point of view, the model arises via a regular perturbation of the Cahn-Hilliard model. While the equilibrium structure of the latter on one-dimensional domains is fully understood, a complete description of the diblock copolymer equilibrium structure is still unknown. In this talk we describe some results which describe the formation of energy minimizers with fine structure through a homotopy from the classical Cahn-Hilliard bifurcation diagram, as well as related multistability issues.

Speaker: Pawel Pilarczyk (U Minho, Portugal)
Title: Automatic classification of global dynamics in flows with parameters

Abstract: An algorithmic method will be introduced for computing a database of global dynamics on a bounded set in R^n in a multi-parameter family of continuous-time semidynamical systems (flows). By means of a time-1 map, the problem is reduced to the classification of global dynamics in discrete-time semidynamical systems by a method introduced by Arai et al. [SIADS 8 (2009), 757-789]. The global dynamics is represented by means of a combinatorial version of a Morse decomposition. Morse decompositions for adjacent parameter ranges are matched and provide rigorous continuation results. Some applications of this method will also be briefly illustrated.

Speaker: Konstantin Mischaikow (Rutgers U, USA)

Title: A combinatorial approach to dynamics applied to switching networks

Abstract: Models of multiscale systems, such as those encountered in systems biology, are often characterized by heuristic nonlinearities and poorly defined parameters. Furthermore, it is typically not possible to obtain precise experimental data for these systems. Nevertheless, verification of the models requires the ability to obtain meaningful dynamical structures that can be compared quantitatively with the experimental data. With this in mind we present a purely combinatorial approach to modeling dynamics. We will discuss this approach in the context of switching networks.

Speaker: Hidetoshi Morita (Department of Mathematics, Kyoto U)
森田英俊（京都大学・理学研究科）

Title: Application of a topological-computation method to meteorological data

Abstract: Conley-Morse (CM) graph is a topological-computation method to obtain the global phase space structure of a dynamical system in the sense that it gives a gradient-like decomposition (Morse decomposition) into a finite number of isolated invariant sets (Morse sets). The method was originally devised to obtain a mathematically rigorous result with the use of numerical verification method. It has recently been applied to dynamical time series analysis, either deterministic or stochastic.

We apply the last method to meteorological data, i.e., the time series of first several empirical orthogonal functions of reanalysis data, both in troposphere and stratosphere, in the northern hemisphere. This exstracts, from the highly stochastic time series, characteristic distributions of pressure as invariant sets, and transtions between them as gradient relations, which is relevant to facts or insights that meteorologists have shared.

This is a joint work with Masaru Inatsu (Hokkaido) and Hiroshi Kokubu (Kyoto).

Speaker: Hiroe Oka (Department of Applied Mathematics and Informatics, Ryukoku U)
岡宏枝（龍谷大学・理工学部）

Title: Detecting Morse decompositions of the global attractor of regulatory networks by time series data

Abstract: Complex network structure frequently appear in biological systems such as gene regulatory networks, circadian rhythm models, signal transduction circuits, etc. As a mathematical formulation of such biological complex network systems, Fiedler, Mochizuki and their collaborators (JDDE 2013) recently defined a class of ODEs associated with a finite digraph called a regulatory network, and proved that its dynamics on the global attractor can in principle be faithfully monitored by information from a (potentially much) fewer number of nodes called the feedback vertex set of the graph.

In this talk, I will use their theory to give a method for detecting a more detailed information on the dynamics of regulatory networks, namely the Morse decomposition of its

global attractor. The main idea is to take time series data from the feedback vertex set of a regulatory network, and construct a combinatorial multi-valued map, to which we apply the so-called Conley-Morse Database method.

As a test example, we study Mirsky's mathematical model for mammalian circadian rhythm which can be represented as a regulatory network with 21 nodes, and show that numerically generated time series data from its feedback vertex set consisting of 7 nodes correctly detect a Morse decomposition in the global attractor, including 1 stable periodic orbit, 2 unstable periodic orbits, and 1 unstable fixed point.
This is a joint work with B. Fielder, A. Mochizuki, G. Kurosawa, and H. Kokubu.

Speaker: Shaun Harker (Rutgers U, USA)
Title: Space-efficient Algorithms for Computational Dynamics a la Conley-Morse Database

Abstract: Often in algorithmic design, the space bottleneck can be more severe (and expensive to overcome) than the time bottleneck. We overview several space-efficient algorithms and data structures that have been used to implement the computational dynamics software "Conley-Morse Database." In particular we showcase a modified version of Tarjan's algorithm that does not require storage of graph adjacency lists, a method for storing multi scale cubical grids based on succinct data structure techniques, and a method for compressing the database output using memoization techniques.

<u>March 14 (Fri)　3月14日（金）</u>

Speaker: Frederic Chazal (INRIA, France)
Title: Persistence stability for geometric complexes

Abstract: In TDA, persistent homology appears as a fundamental tool to infer relevant topological information from data. Persistence diagrams are usually computed from different geometric filtered complexes (such as Vietoris-Rips, Cech and witness complexes) built on top of data sets sampled from some unknown (metric) space. They provide "topological signatures" revealing the structure of the underlying space. To ensure the relevance of such signatures, it is necessary to prove that they come with stability properties with respect to the way data are sampled. In this first talk, using recent developments in the theory of topological persistence, we will provide simple and natural proofs of the stability of the persistent homology of such complexes with respect to the Gromov-Hausdorff distance. We will also exhibit a few noteworthy properties of the homology of the Rips and Cech complexes built on top of compact spaces. This is a joint work with V. de Silva and S. Oudot

Reference:
F. Chazal, V. de Silva and S. Oudot, Persistence stability for geometric complexes, Geometriae Dedicata (online first: Dec 6, 2013).

Speaker: Kelly Spendlove (Rutgers U, USA)
Title: Persistent Topological Analysis of Human Red Blood Cells and Flickering

Abstract: Human red blood cells (RBCs) exhibit spontaneous vibratory motions, referred to as flickering. Previous work using detrended fluctuation analysis and multiscale entropy methods has shown that the short-term flickering motions of RBCs, observed using single or small groupings of pixels from phase contrast microscopy images, have a fractal scaling exponent close to that of 1/f noise and exhibit complex dynamics over multiple time scales. In addition, these dynamical properties were shown to degrade with in vivo aging such that older cells that have been in circulation longer generate significantly less complexity than newly formed cells. Using persistent homology, we present analogous results for quantifying spatial and spatiotemporal characteristics of RBC flickering, and their changes with in vivo aging.

Speaker: Yasuaki Hiraoka (Institute of Mathematics for Industry, Kyushu U)
平岡裕章（九州大学・マスフォアインダストリ研究所）

Title: Persistence of Common Topological Structures by a Commutative Triple Ladder Quiver

Abstract: In this talk, I present a new method to detect robust common topological structures of two geometric objects. The idea is to extend the notion of persistent homology to representations on a commutative triple ladder quiver.

(i) I show that representations on the commutative triple ladder quiver are finite type.

(ii) The Auslander-Reiten quiver of the commutative triple ladder, which lists up all the possible isomorphism classes of indecomposable persistence modules and irreducible morphisms among them, is explicitly derived. In addition, the notion of persistence diagrams is generalized to graphs on the Auslander-Reiten quiver.

(iii) An algorithm for computing indecomposable decompositions by using the Auslander-Reiten quiver is presented.

(iv) A numerical example to detect robust common topological features is shown.

Speaker: Frederic Chazal (INRIA, France)

Title: Statistical properties of persistence diagrams in Topological Data Analysis

Abstract: In this second talk, we will show that the use of persistence homology can be naturally considered in general statistical frameworks. Using stability properties of persistent homology, we will show how persistence diagrams can be used as statistics with interesting convergence properties. We will also present a variant of persistence diagrams, the persistence landscapes, that reveals interesting properties, both from the statistical and computational points of view. These are joint works with B. Fasy, M. Glisse, C. Labruere, F. Lecci, B. Michel, A. Rinaldo and L. Wasserman.

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F. Chazal, M. Glisse, C. Labruere, B. Michel, Convergence rates for persistence diagram estimation in Topological Data Analysis, to appear in ICML 2014.

F. Chazal, B. Fasy, F. Lecci, A. Rinaldo and L. Wasserman. Stochastic Convergence of Persistence Landscapes and Silhouettes, to appear in ACM Symp. on Comp. Geometry 2014.