First Global COE Seminar on Mathematical Research Using Computers

PROGRAM

**Most of the talks will be in Japanese.*

Friday, October 24

14:00-15:00 **Shizuo Kaji (Fukuoka University)**
Computers Work Exceptionally on Lie Groups

The well known classification theorem states that there are only nine types of simple compact Lie groups; the four classical infinite families and the five exceptional ones. Although topological invariants of classical Lie groups are often given in simple unified forms, those of exceptional groups are usually of ugly looks, which insist on handling by a case by case analysis; this is where computers would do themselves justice. By presenting an example of the computation of the Chow rings of complex Lie groups, I will demonstrate the possibility of using a computer in such a kind of research where tedious and technical labor is required.

15:15-16:15 **Hiroyuki Inou (Kyoto University)**
Complex Dynamics and Computer

Complex dynamics is an area that developed rapidly after computer appeared. In this talk, I would like to explain how computer is useful to understand various phenomena in complex dynamics, especially to understand fractal sets which appear as invariant sets in the phase space (Julia sets) and bifurcation loci (e.g., the Mandelbrot set) in parameter spaces. If time allows, I would also mention some recent results using rigorous computation and computability.

16:30-17:30 **Tomohiro Fukaya (Kyoto University)**
Computer Algebra and Algebraic Topology

Algebraic topology translates the problem of TOPOLOGY into the problem of ALGEBRA. LS-category is a simple but quite difficult invariant in topology. However, it's algebraic translation, cup-length is easier to calculate. Indeed, sometimes it is translated into the problem of (multi-variable) polynomial ring. Groebner basis enable us to study those rings quite systematically. I studied cup-length of some spaces using Groebner basis and computer, then I obtained some results on the LS-category of those spaces. In this talk, I will explain those "translation of problems" and my observation of results of calculation by computer.

Party (Free discussion)

Saturday, October 25

10:30-11:30 **Pawel Pilarczyk (Univ. Minho, Portugal)**
The Computational Homology Project (CHomP) and Its Software for Mathematical computing

This talk is supposed to be an introduction to the software for automatic homology computation published at the website of the Computational Homology Project http://chomp.rutgers.edu/. In addition to describing the software itself and explaining how to use it, a variety of applications will also be discussed. The core of the software is an efficient library of homology computation routines programmed in C++ and published with source code under the terms of the GNU General Public License. The downloadable package comes equipped with easy to use command-line programs for convenient access to the features of this library. The software provides algorithms for the homology computation at the abstract algebraic level (chain complexes), and also efficient techniques combined with geometric reduction methods for the homology computation of simplicial complexes and cubical complexes. (Cubical complexes are cellular complexes built upon a rectangular lattice in R^n.) In the latter case, computation of the homomorphisms induced in homology for continuous maps is also supported, provided the map can be represented in a suitable way. In this talk, brief introduction to the concept of homology will be given, an overview of algorithms will be provided, basic examples of homology computation will be explained, and more advanced applications and open directions of research will be discussed.

11:45-12:45 **Marcio Gameiro (Kyoto University)**
Applications of Computational Homology to the Analysis of Complicated Spatio-Temporal Patterns

We will discuss some applications of computational homology to the analysis of patterns arising from numerical simulations of PDEs and from experiments. When the patterns are given in the form of images, or they arise from simulations of PDEs in rectangular grids, they can naturally be represented as cubical sets, which is the natural input for CHomP. We then use CHomP to extract basic topological information from the patterns, and use this topological information to draw conclusions about the patterns. It may be possible for example, to identify patterns at different parameter values. This can be applied to a wide variety of patterns and is dimension independent. We will present examples of patterns generated by the FitzHugh-Nagumo and the Cahn-Hilliard equations defined on two-dimensional rectangular domains.

14:30-15:30 **Shunsuke Tsuchioka (Kyoto University)**
Hints for Utilizing Computers to Mathematical Research

In doing mathematical research, computers are useful to confirm facts in small examples and figure conclusions out. But in practice for students majoring mathematics, it is often difficult to implement an algorithm in their mind and calculate what they want. In this talk, we point out where difficulties live and propose hints to utilize computers.

15:45-16:45 **Zin Arai (Hokkaido University)**
Computers and Chaos

When a dynamical system is "chaotic", any small error in the initial condition of the system grows with time, which makes the presice prediction of the system impossible. On the other hand, numerical errors are unavoidable when we use a computer to calculate the orbit of the system. Does this means the computational study of chaotic systems is impossible? In this talk, we introduce some ideas to overcome this difficulty.