Workshop
Topology and Computer 2017

A workshop "Topology and Computer 2017" will be held as follows. This Workshop is supported by Grant-in-Aid Scientific Research (S) No. 15H05739 (Koji Fujiwara, Kyoto University) , JSPS 受託学術動向調査研究 (Sadayoshi Kojima, Tokyo Institute of Technology), Grant-in-Aid Scientific Research (C) No. 26400100 (Kazuhiro Ichihara, Nihon University) and Grant-in-Aid for Young Scientists (B) No. 15K17540 (Tetsuya Ito, Osaka University) .

Date: October 20 – 22, 2017
Venue: Osaka University, Toyonaka Campus,
School & Graduate School of Engineering Science, International building, Seminar room
Address: 1-1 Machikaneyama-cho, Toyonaka, Osaka, Japan
Web: http://www.math.akita-u.ac.jp/tc2017/index-e.html

Program

October 20

13:30 – 14:00 Yusuke Inagaki (Osaka University)
On Fuchsian locus of PSL$(n, \mathbb{R})$-Hitchin component for a pair of pants

14:15 – 14:45 Jimenez Pascual, Adrian (The University of Tokyo)
On adequacy and the crossing number of satellite knots

15:00 – 15:30 Ken'ichi Yoshida (Kyoto University)
Parametrization for intersecting 3-punctured spheres in hyperbolic 3-manifolds

15:50 – 16:20 Hidetoshi Masai (Tohoku University)
Topological entropy of random walks on mapping class groups

16:40 – 17:20 Hiroki Sumi (Kyoto University)
Finding roots of any polynomial by random relaxed Newton's methods

October 21

9:30 – 10:00 Yasuhiro Hara (Osaka University)
Homology groups of neighborhood complexes of graphs

10:15 – 10:45 Hirotaka Akiyoshi (Osaka City University)
Experiments on Ford and Dirichlet domains for 3-dimensional cone hyperbolic manifolds

11:00 – 11:30 Kento Nakamura (Meiji University)
Polyhedra with spherical faces and quasi-Fuchsian fractals

11:50 – 12:30 Jonathan Spreer（Freie Universität Berlin）
Telling 3-manifolds apart: new algorithms to compute Turaev-Viro invariants

14:30 – 14:45 Eri Kamikawa (Meiji University)
Towards an integrated knot diagram editor on smartphone

14:45 – 15:00 Takeki Sudo (Meiji University)
Cubical Ripser - A calculator of the persistent homology of the cubical complex

15:20 – 16:00 Tomohiro Tachi (The University of Tokyo)
Configuration space of rigidly foldable origami

16:20 – 16:50 Tsuyoshi Kobayashi (Nara Women's University)
Some geometric structures that appear in origami

17:10 – 17:50 Tadayuki Watanabe (Shimane University)
On the 4-dimensional smooth Smale conjecture

October 22

9:30 – 10:00 Han Yoshida (National Institute of Technology, Gunma College)
Volume and commensurability of non-arithmetic hyperbolic 3-orbifolds

10:20 – 11:00 Jonathan Spreer（Freie Universität Berlin）
simpcomp – Computational topology in GAP

11:20 – 11:50 Ryosuke Yamazaki (Gakushuin Boys' Senior High School)
The realization problem for Jørgensen numbers （joint work with Yasushi Yamashita）

12:10 – 12:50 Tatsuyoshi Hamada (Nihon University)
An introduction of dynamic mathematical software, GeoGebra

Organizers: Yasuharu Nakae (Akita University), Tetsuya Ito (Osaka University), Kazuhiro Ichihara (Nihon University)

Abstracts

October 20

13:30 – 14:00 Yusuke Inagaki (Osaka University)
On Fuchsian locus of PSL$(n, \mathbb{R})$-Hitchin component for a pair of pants

Hitchin components are connected components of character varieties for surface groups. They contain Teichmuller spaces by their definition and the locus of Hitchin components which corresponds to Teichmuller spaces is called Fuchsian locus. In this talk we give an explicit description of the Fuchsian locus of PSL$(n, \mathbb{R})$-Hitchin components for a pair of pants under the Bonahon-Dreyer's parametrization.

14:15 – 14:45 Jimenez Pascual, Adrian (The University of Tokyo)
On adequacy and the crossing number of satellite knots

It has always been difficult to prove results regarding the (minimal) crossing number of knots. Focusing on the case of satellite knots, from the time of Kirby's list of Problems in Low-Dimensional Topology and before, it remains to be proven that the crossing number of $Sat(P, C)$ is at least bigger than the crossing number of C itself. In this occasion, I present several results regarding adequate knots, to finally give a positive answer to this unsolved problem when the satellite knots are built using adequate knots.

15:00 – 15:30 Ken'ichi Yoshida (Kyoto University)
Parametrization for intersecting 3-punctured spheres in hyperbolic 3-manifolds

In this talk, we consider intersecting 3-punctured spheres which form a line in a hyperbolic 3-manifold. The metric of a neighborhood of such 3-punctured spheres is determined by the modulus of an adjacent cusp. Moreover, the set of such moduli becomes smaller as the number of 3-punctured spheres increases. We describe the set of moduli, and give some computational examples.

15:50 – 16:20 Hidetoshi Masai (Tohoku University)
Topological entropy of random walks on mapping class groups

We discuss how efficiently random sequences of mapping classes "mix" the surface. The goal of this talk is to see that dynamics given by such random sequences behave similarly to deterministic dynamics by pseudo-Anosovs.

16:40 – 17:20 Hiroki Sumi (Kyoto University)
Finding roots of any polynomial by random relaxed Newton's methods

In this talk, we develop the theory of random holomorphic dynamics. Applying it to finding roots of polynomials by random relaxed Newton's methods, we show that for any polynomial g, for any initial value $z \in \mathbb{C}$ which is not a root of g', the random orbit starting with z tends to a root of g almost surely, which is the virtue of the effect of the randomness. (That kind of statement cannot hold for the deterministic Newton's method and its relatives.) For the preprint, see H. Sumi, Negativity of Lyapunov Exponents and Convergence of Generic Random Polynomial Dynamical Systems and Random Relaxed Newton's Methods, `https://arxiv.org/abs/1608.05230`

October 21

9:30 – 10:00 Yasuhiro Hara (Osaka University)
Homology groups of neighborhood complexes of graphs

The neighborhood complex $N(G)$ of a graph G was introduced by Lovász to determine the chromatic number of Kneser graphs. In this talk, we introduce a calculation of the homology groups of $N(G)$ and the relationship between the homology groups of $N(G)$ and the chromatic number of G. Moreover, we introduce the circular chromatic number and its related graphs and study on the homology groups of their neighborhood complexes.

10:15 – 10:45 Hirotaka Akiyoshi (Osaka City University)
Experiments on Ford and Dirichlet domains for 3-dimensional cone hyperbolic manifolds

Let us consider the problem of determining when a given pair of orientation-preserving isometries of the hyperbolic 3-space generates a discrete group. In the case when the commutator of the given elements is parabolic, the "Jorgensen theory" gives an efficient algorithm for the problem, which is implemented as OPTi by Masaaki Wada, many numerical experiments by Yasushi Yamashita, and so on. The goal of our project is to establish an analogous theory for the case with elliptic commutator, where we employ both Ford domains and Dirichlet domains for producing certain canonical objects. In the talk, a computer software under construction will be shown.

11:00 – 11:30 Kento Nakamura (Meiji University)
Polyhedra with spherical faces and quasi-Fuchsian fractals

In 2002, Kazushi Ahara and Yoshiaki Araki proposed a geometrical concept called Sphairahedron. Sphairahedron is a polyhedron with spherical faces. We can consider Coxeter-like group generated by each inversion in the sphere which defines the face of the sphairahedron. When the sphairahedron is "ideal" and "regular", the group becomes a quasi-Fuchsian group. We can consider classification problem of ideal regular sphairahedron. The limit set of the group has a fractal structure called quasi-sphere. The image of quasi-sphere is one of the early examples of 3-dimensional fractals. However, the shape of the quasi-sphere and its parameter space is known only by cube-type sphairahedron.

In this talk, we show other types of ideal regular sphairahedron and images of the quasi-sphere. Visualization of quasi-sphere is usually time-consuming processing. The speaker develops the software rendering a sphairahedron and quasi-sphere in real-time with a kind of ray tracing technique.

11:50 – 12:30 Jonathan Spreer (Freie Universität Berlin)
Telling 3-manifolds apart: new algorithms to compute Turaev-Viro invariants

In low-dimensional topology, distinguishing between manifolds is a fundamental problem, which is remarkably difficult to solve in dimensions beyond two. As a result, topologists rely on simpler invariants to solve this task. In dimension three, the family of Turaev-Viro invariants are amongst the most powerful invariants, but standard algorithms to compute them have prohibitive running times for numerous instances occurring in practice.

I will discuss how Turaev-Viro invariants can be defined in a purely combinatorial way, and present two new algorithms to compute them. Both algorithms use the framework of parameterised complexity – but in fundamentally distinct ways. Both algorithms can be implemented and have faster running times than the previous state-of-the-art algorithm.

This is joint work with Benjamin Burton and Clément Maria.

14:30 – 14:45 Eri Kamikawa (Meiji University)
Towards an integrated knot diagram editor on smartphone

It is difficult for beginners of knot theory to copy a knot diagram which is printed in the textbooks and papers onto notebooks and apply Reidemeister moves to the knot diagram by hand. Thus, in this study, we propose a system which captures an image of a knot diagram by smartphone and extracts the data of the knot diagram such as curves and crossings. In the last presentation, we implemented the system by processing. This time we develop the system by java on android studio for android machine. This system can recognize pictures taken by camera application of android and it allows users to modify the knot diagram on the touch screen device. In the future we want to implement a function of manipulating Reidemeister moves on this system as in the former version.

14:45 – 15:00 Takeki Sudo (Meiji University)
Cubical Ripser - A calculator of the persistent homology of the cubical complex

Persistent homology (PH) is widely used to describe robust and noisy topological properties in data. Developing software to calculate the PH of huge amount of data accurately and quickly is desired. In this talk, we will introduce the algorithm of the software "Ripser" (by Bauer in 2016) which calculates the PH of a Vietoris-Rips complex. Then, we propose the software "Cubical Ripser" (by the authors in 2017) which calculates the PH of a cubical complex using Ripser's algorithm. The execution speed of Cubical Ripser is over 4 times faster than that of DIPHA, the best existing software.

15:20 – 16:00 Tomohiro Tachi (The University of Tokyo)
Configuration space of rigidly foldable origami

Rigid origami mechanisms, i.e., rigid-plate-and-hinge mechanisms, can be applied to the design of deployable and transformable structures. Unlike generic mechanisms where the degrees of freedom can be evaluated by the rank of the Jacobian matrix, rigid origami utilizes its flat, singular state where the configuration space bifurcates. The bifurcation makes the folding of origami more difficult than unfolding; in fact, the solving the kinematics of origami is computationally hard (at least NP-hard). On the other hand, this bifurcating property leads to the designs of mode switching systems that may lead to new designs of microrobots.

16:20 – 16:50 Tsuyoshi Kobayashi (Nara Women's University)
Some geometric structures that appear in origami

Folding patterns inspired by origami has many applications in our real life, for example in spaceship, robot technology, and in medical technology. Particularly, origami that can be folded in a flat shape is called a flat-foldable-origami, and it is useful from the viewpoint of practical applications. In this talk, I will introduce certain relationships

between flat-foldable-origami and some geometric structures (concretely speaking, similarity structure and 2-dimensional Euclidean orbifold structure). Then I will pose a question related to the topic.

17:10 – 17:50 Tadayuki Watanabe (Shimane University)
On the 4-dimensional smooth Smale conjecture

The Smale conjecture states that the inclusion of the orthogonal group $O(4)$ into the group $\mathrm{Diff}(S^3)$ of diffeomorphisms of the 3-sphere is a homotopy equivalence, and was proved by A. Hatcher. There is a 4-dimensional analogue of the Smale conjecture, which states that the inclusion of $O(5)$ into $\mathrm{Diff}(S^4)$ is a homotopy equivalence. We propose a method to disprove the 4-dimensional Smale conjecture. We evaluate Kontsevich's characteristic classes on some smooth D^4-bundles constructed by an analogue of graph clasper surgery (or sugery on Y-graphs) of Goussarov–Habiro. Then the proof is reduced to checking the non-triviality of the even-dimensional version of Kontsevich's graph homology, part of which has been computed by D. Bar-Natan and B. McKay with the aid of a computer.

October 22

9:30 – 10:00 Han Yoshida (National Institute of Technology, Gunma College)
Volume and commensurability of non-arithmetic hyperbolic 3-orbifolds

C. Adams showed that the 6 smallest volumes for orientable cusped hyperbolic 3-orbifolds are $\frac{v_0}{12}$, $\frac{v_1}{6}$, $\frac{v_0}{6}$, $\frac{v_0}{6}$, $\frac{5v_0}{24}$ and $\frac{v_1}{4}$ ($v_0 = vol(\text{regular ideal tetrahedron}) = 1.0149\cdots$, $v_1 = vol(\text{regular ideal octahedron})/4 = 0.915\cdots$). W. Neumann and A. Reid showed these six orbifolds are arithmetic. In this talk, I show that the 14 smallest volumes for orientable cusped hyperbolic 3-orbifolds are $\frac{v_0}{12}$, $\frac{v_1}{6}$, $\frac{v_0}{6}$, $\frac{v_0}{6}$, $\frac{5v_0}{24}$, $\frac{v_1}{4}$, $\frac{v_0}{4}$, $\frac{v_1}{3}$, $\frac{v_1}{3}$, $\frac{v_1}{3}$, $\frac{v_0}{3}$, $\frac{v_0}{3}$, $\frac{v_0}{3}$ and $\frac{v_2}{60}$. $\frac{v_2}{60} = 0.343\cdots$ is the minimal volume of orientable non-arithmetic cusped hyperbolic 3-orbifold ($v_2 = vol(\text{reg. ideal dodecahedron})$).

10:20 – 11:00 Jonathan Spreer (Freie Universität Berlin)
simpcomp – Computational topology in GAP

The combinatorial topology software simpcomp (joint work with Felix Effenberger) is an extension – a so called package – to the open source computer algebra system GAP. Its primary purpose is to provide functionality to deal with simplicial complexes within the GAP framework.

In this talk I will give a brief overview over the capabilities of simpcomp. This is followed by a number of examples how simpcomp – together with other GAP features – can be used to perform research tasks in computational topology and related areas.

11:20 – 11:50 Ryosuke Yamazaki (Gakushuin Boys' Senior High School)
The realization problem for Jørgensen numbers (joint work with Yasushi Yamashita)

Hiroki Sato defined the Jørgensen number of a two-generator Kleinian group as a generalization of Jørgensen's inequality. Oichi-Sato asked the following natural problem : for any real number $r \geq 1$, when is there a Kleinian group whose Jørgensen number is equal to r? In this talk, we will give a complete solution for this realization problem.

12:10 – 12:50 Tatsuyoshi Hamada (Nihon University)

An introduction of dynamic mathematical software, GeoGebra

GeoGebra is a dynamic mathematical software. It is developed for learning and teaching mathematics in schools by Markus Hohenwarter and an international team of programmers. GeoGebra supports not only Windows and Mac but also iPhone, iPad and Android devices. GeoGebra is a rapidly expanding community of millions of users located in just about every country. In this talk, we introduce how to use GeoGebra for teaching calculus, curves and surfaces.