研究集会
「トポロジーとコンピュータ 2017」

トポロジー研究連絡会議の支援するトポロジープロジェクトの一環として，平成 29 年度科学研究費補助金基盤研究 (S)「幾何学的群論の深化と展開」（研究代表者：藤原耕二, 課題番号 15H05739），JSPS 受託学術動向調査研究（代表：小島定吉（東工大情報））, 平成 29 年度科学研究費補助金基盤研究 (C)「交代結び目に関する矯飾的手術予想」（研究代表者：市原一裕, 課題番号 26400100）, 平成 29 年度科学研究費補助金若手研究 (B)「群の順序構造による視点からのトポロジーの研究とその応用」（研究代表者：伊藤哲也, 課題番号 15K17540）の協力を受け， 下記の日程で研究集会「トポロジーとコンピュータ 2017」を開催致します。

日時：2017 年 10 月 20 日（金）午後 〜 22 日（日）午前
場所：大阪大学豊中キャンパス基礎工学部国際棟セミナー室
住所：大阪府豊中市待兼山町 1-1
Web: http://www.math.akita-u.ac.jp/tc2017/index.html

プログラム

10 月 20 日（金）

13:30 – 14:00 稲垣 友介（大阪大学）
On Fuchsian locus of PSL$(n, \mathbb{R})$-Hitchin component for a pair of pants

14:15 – 14:45 Jimenez Pascual, Adrian（東京大学）
On adequacy and the crossing number of satellite knots

15:00 – 15:30 吉田 建一（京都大学）
Parametrization for intersecting 3-punctured spheres in hyperbolic 3-manifolds

15:50 – 16:20 正井 秀俊（東北大学）
Topological entropy of random walks on mapping class groups

16:40 – 17:20 角 大輝（京都大学）
Finding roots of any polynomial by random relaxed Newton's methods

10 月 21 日 (土)

9:30 – 10:00 原 靖浩（大阪大学）
Homology groups of neighborhood complexes of graphs

10:15 – 10:45 秋吉 宏尚（大阪市立大学）
３次元錐双曲多様体のフォード領域とディリクレ領域に関する実験

11:00 – 11:30 中村 建斗（明治大学）
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 上河 恵理（明治大学）
Towards an integrated knot diagram editor on smartphone

14:45 – 15:00 須藤 丈稀（明治大学）
Cubical Ripser - A calculator of the persistent homology of the cubical complex

15:20 – 16:00 舘 知宏（東京大学）
剛体折紙のコンフィギュレーション空間

16:20 – 16:50 小林 毅（奈良女子大学）
折り紙に現れる幾つかの幾何構造について

17:10 – 17:50 渡邉 忠之（島根大学）
On the 4-dimensional smooth Smale conjecture

10 月 22 日 (日)

9:30 – 10:00 吉田 はん（群馬工業高等専門学校）
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 山崎 亮介（学習院高等科）
The realization problem for Jørgensen numbers （joint work with Yasushi Yamashita）

12:10 – 12:50 濱田 龍義（日本大学）
動的数学ソフトウェア GeoGebra 入門

世話人：中江康晴（秋田大学）, 伊藤哲也（大阪大学）, 市原一裕（日本大学文理学部）

アブストラクト

10月20日（金）

13:30 – 14:00 稲垣 友介（大阪大学）

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（東京大学）

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 吉田 建一（京都大学）

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 正井 秀俊（東北大学）

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 角 大輝（京都大学）

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`

10月21日 (土)

9:30 – 10:00 原 靖浩（大阪大学）
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 秋吉 宏尚（大阪市立大学）
３次元錐双曲多様体のフォード領域とディリクレ領域に関する実験

３次元双曲空間の向きを保つ等長変換２つの組が与えられたとき，それらが生成する群がいつ離散的であるかという基本的な問題を考えたい．与えられた変換の交換子積が放物型である場合には，穴あきトーラスクライン群に対するいわゆる Jorgensen 理論が有効であることが和田昌昭氏による OPTi や山下靖氏による様々な数値実験などを通して実証されている．この研究では，交換子積が楕円型である場合の同種の理論の構築をゴールとして目指している．そこでは Jorgensen 理論で用いられたフォード領域だけでなく，ディリクレ領域も同時に考えると自然な考察が行えると期待している．講演では，この研究のために開発中のソフトを紹介する．

11:00 – 11:30 中村 建斗（明治大学）
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 上河 恵理（明治大学）

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 須藤 丈稀（明治大学）

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 舘 知宏（東京大学）

剛体折紙のコンフィギュレーション空間

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 小林 毅（奈良女子大学）

折り紙に現れる幾つかの幾何構造について

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 渡邉 忠之（島根大学）
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.

10月22日 (日)

9:30 – 10:00 吉田 はん（群馬工業高等専門学校）
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 山崎 亮介（学習院高等科）
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　濱田 龍義（日本大学）

動的数学ソフトウェア GeoGebra 入門

動的数学ソフトウェア GeoGebra はオーストリア，ヨハネスケプラー大学の Markus Hohenwater 教授を中心とするグループによって開発が進められている数学教育用ツールである．Windows や Mac 等のコンピュータだけでなく，iPhone や Android スマートフォン等でも動作するため，世界中で利用されている．本講演では，初歩的な曲線論や曲面論を題材に，GeoGebra の活用方法について紹介する予定である．