

研究集会 「トポロジーとコンピュータ 2016」

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 28 年度科学研究費補助金基盤研究 (B)「曲面と 3 次元多様体が相互に絡むトポロジー」(研究代表者：小島 定吉, 課題番号：15H03619) 他の支援を受け、下記の日程で研究集会「トポロジーとコンピュータ 2016」を開催致します。

日時：2016 年 10 月 28 日 (金) 午後 ~ 30 日 (日) 午前
場所：カレッジプラザ 講堂 (JR 秋田駅より徒歩 8 分)
住所：秋田市中通 2 丁目 1 - 5 1 明德館ビル 2 階
Web: <http://www.math.akita-u.ac.jp/tc2016/index.html>

プログラム

10 月 28 日 (金)

- 13:30 – 14:15 蒲谷 祐一 (北見工業大学)
Optimal Kazhdan constants and semidefinite programming
- 14:30 – 15:15 草野 元紀 (東北大学)
パーシステントホモロジーの統計解析
- 15:30 – 16:15 児玉 大樹 (東京大学)
タンパク質構造解析と $SO(3)$
- 16:30 – 17:15 Szilárd Zsolt Fazekas (秋田大学)
Regular languages closed under word operations
- 17:30 – 18:00 鈴木 正明 (明治大学)
Epimorphisms between two-bridge knot groups and their crossing numbers

10 月 29 日 (土)

- 9:30 – 10:00 長郷 文和 (名城大学)
幽霊指標, 指標多様体と可換ノットコンタクトホモロジー
- 10:05 – 10:30 鈴木 心之助 (名城大学)
結び目に沿って分岐する 3 次元球面の 2 重分岐被覆の基本群の $SL(2, C)$ -表現について
- 10:45 – 11:30 田島 慎一 (筑波大学)
Limiting tangent spaces and local cohomology
- 13:00 – 13:45 Alden Walker (Center for Communication Research)
Surface subgroups from linear programming

- 14:00 – 14:15 上河 恵理 (明治大学)
結び目の正則図形の画像から画像認識するシステム
- 14:20 – 14:35 力石 優武 (明治大学)
BeadsKnot - A knot drawing system which allows us to simulate Reidemister Moves
- 14:40 – 14:55 中村 建斗 (明治大学)
An interactive visualization system on a family of Kleinian groups based on Schottky groups
- 15:10 – 15:55 縫田 光司 (産業技術総合研究所)
トポロジーを暗号に応用したい
- 16:10 – 16:40 逆井 卓也 (東京大学)
An abelian quotient of the symplectic derivation Lie algebra of the free Lie algebra
- 16:50 – 17:35 高山 (西) 晴子 (城西大学)
Polyhedral structures of the configuration space of points on P^1

10月30日 (日)

- 9:30 – 10:00 清水 理佳 (群馬工業高等専門学校)
Reductivity problem on knot projections
- 10:10 – 10:55 Alden Walker (Center for Communication Research)
Rigorous mathematical certificates
- 11:10 – 11:40 若月 駿 (東京大学)
Computation of string operations using rational homotopy theory
- 11:50 – 12:35 和田昌昭 (大阪大学)
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世話人：市原一裕 (日本大学文理学部), 中江康晴 (秋田大学)

アブストラクト

10月28日(金)

13:30 – 14:15 蒲谷 祐一 (北見工業大学)

Optimal Kazhdan constants and semidefinite programming

Narutaka Ozawa found a new necessary and sufficient criterion for Kazhdan's property (T) for finitely generated groups, which gives an explicit lower bound of the spectral gap, and the Kazhdan constant. Using his criterion with semidefinite programming, Netzer-Thom gave a lower bound of the Kazhdan constant for $SL_3(\mathbb{Z})$ with respect to the generating set given by elementary matrices. This improved the previous results by Shalom, Kassabov. I will show more examples and computations.

14:30 – 15:15 草野 元紀 (東北大学)

パーシステントホモロジーの統計解析

In topological data analysis(TDA), a persistent homology is widely used to describe the robust and noisy topological properties in data, and it has a compact form called a persistence diagram. In this talk, I will propose a kernel method for persistence diagrams to develop a statistical framework in TDA. Then, a new distance on persistence diagrams is defined by our kernel, and satisfies the stability property. As an application, we show that our method can clearly detect the glass transition temperature in SiO₂ from their geometric structures.

15:30 – 16:15 児玉 大樹 (東京大学)

タンパク質構造解析と $SO(3)$

タンパク質は20種類からなるアミノ酸が鎖状に重合してできたポリペプチドが、さらに水素結合などにより複雑な立体構造を得た高分子である。

本講演では、隣り合うペプチドユニット同士の相対的な向きを回転群 $SO(3)$ を用いて表すことによる、タンパク質の立体構造のモデリングを提唱し、実際のタンパク質への応用について述べる。

また、J. E. Andersen らによるタンパク質の折りたたみ問題への応用についても紹介する。

16:30 – 17:15 Szilárd Zsolt Fazekas (秋田大学)

Regular languages closed under word operations

The central topic of the talk is the extension of iterated word operations to all words of a given language. Several word operations have been considered in this context, such as duplication, power operation, pseudopalindromic completion and iterated hairpin completion. For some of these operations the result of applying them a regular language is not necessarily regular. The decidability of whether the resulting language is regular is a hard problem in most cases. We present a survey of the cases when the result is always regular as well as characterization and related decidability theorems in the other cases.

17:30 – 18:00 鈴木 正明 (明治大学)

Epimorphisms between two-bridge knot groups and their crossing numbers

In this talk, we consider the relationship between epimorphisms of two-bridge knot groups and their crossing numbers. In particular, if there exists an epimorphism from the knot group of a two-bridge knot K onto that of another knot K' , then the crossing number of K is greater than or equal to three times of that of K' . Moreover, we formulate the generating function which determines the number of two-bridge knot groups admitting epimorphisms onto the knot group of a given two-bridge knot.

10月29日(土)

9:30 – 10:00 長郷 文和 (名城大学)

幽霊指標, 指標多様体と可換ノットコンタクトホモロジー

結び目 K の trace-free 指標 $S_0(K)$ を用いて, K の幽霊指標という概念を導入する. 幽霊指標は, K の次数 0 可換ノットコンタクトホモロジー $HC_0^{ab}(K)$ と, 3次元球面の K に沿った 2重分岐被覆 $\Sigma_2 K$ の基本群の指標多様体 $X(\Sigma_2 K)$ との関係を示すための良い道具であり, これを用いて, 以下についての判定法を与える:

- (1) 上記 $HC_0^{ab}(K)$ と $X(\Sigma_2 K)$ との関係についての Ng 予想が成立するか否か,
- (2) 論文 [F. Nagasato-Y. Yamaguchi: On the geometry of the slice of trace-free $SL_2(\mathbb{C})$ -characters of a knot group, Math. Ann. **354** (2012), 967–1002] で与えられた写像 $\widehat{\Phi}: S_0(K) \rightarrow X(\Sigma_2 K)$ がいつ全射にならないか.

10:05 – 10:30 鈴木 心之助 (名城大学)

結び目に沿って分岐する 3次元球面の 2重分岐被覆の基本群の $SL(2, \mathbb{C})$ -表現について

この講演では, ある結び目に沿って分岐する 3次元球面の 2重分岐被覆の基本群を具体的に計算し, その $SL(2, \mathbb{C})$ -表現と幽霊指標についての関係を与える. これにより, 論文 [F. Nagasato-Y. Yamaguchi: On the geometry of the slice of trace-free $SL_2(\mathbb{C})$ -characters of a knot group, Math. Ann. **354** (2012), 967–1002] で与えられた写像 $\widehat{\Phi}: S_0(K) \rightarrow X(\Sigma_2 K)$ が全射にならない例を挙げる.

10:45 – 11:30 田島 慎一 (筑波大学)

Limiting tangent spaces and local cohomology

The concept of a limiting tangent space was introduced by H. Whitney in his study of stratifications. Limiting tangent spaces have been extensively utilized in various ways in singularity theory, especially in problems that involve Whitney stratifications.

In this talk, limiting tangent hyperplanes associated with hypersurface isolated singularities are considered in the context of symbolic computation. A new effective method is proposed to compute the limiting tangent space of a given hypersurface. The key of the proposed method is the concept of parametric local cohomology systems. Proposed method can provide the decomposition of the limiting tangent space by Milnor numbers of hyperplane sections of a given hypersurface. The resulting algorithm has been implemented in the computer algebra system Risa/Asir.

13:00 – 13:45 Alden Walker (Center for Communication Research)

Surface subgroups from linear programming

Gromov asked whether every one-ended hyperbolic group contains a subgroup isomorphic to the fundamental group of a closed hyperbolic surface. The question is still open in general, but the answer is known to be "yes" in many infinite families of groups. In this talk, I'll give the proof for random HNN extensions of free groups. In this case, we describe a certificate which guarantees the existence of a surface subgroup, and we show how to produce this certificate in a random HNN extension. We also use the certificate computationally to prove the existence of a surface subgroup in a specific HNN extension which was conjectured not to contain such a subgroup. This is joint with Danny Calegari.

14:00 – 14:15 上河 恵理 (明治大学)

結び目の正則図形の画像から画像認識するシステム

For beginners of knot theory, it is difficult to copy a knot diagram on textbooks and papers onto their notebooks. It is also confusing for anyone to modify knot diagrams on their notebooks. In this study, we propose a system which captures an image and a photo of a knot diagram and recognizes curves and crossings from the image to extract the data of the knot diagram. First, this system divides the image into small squares and recognizes a line segment which is appeared in each square to get the graph structure. Next, it removes thorn shaped segments and add a segment at a gap and recognizes the shapes of crossings. Here, this procedure might fail because of the size of division, the system estimates the thickness of lines from the original image and tries the process several times by changing the size of squares. Thus it modifies the obtained picture of the knot with double spring scheme devised by Mr. Rikiishi. In the future, we develop a system which allows learners of knot theory to transform and manipulate knot diagrams on the screen over our system.

14:20 – 14:35 力石 優武 (明治大学)

BeadsKnot - A knot drawing system which allows us to simulate Reidemister Moves

In ' topology and computer 2015 ', the speaker presented on a system BeadsKnot, which allows users to edit knot diagrams on the screen and to apply smoothing operation. In this system, a knot diagram is represented by beads and segments. In this talk we introduce a new version of BeadsKnot that was added three types of Reidemeister moves. Users are allowed to operate Reidemeister moves by a mouse dragging. The system can determine the type of Reidemeister move only from the mouse cursor track.

14:40 – 14:55 中村 建斗 (明治大学)

An interactive visualization system on a family of Kleinian groups based on Schottky groups

We developed an algorithm for drawing images of a family of Kleinian groups based on Schottky groups. This algorithm is called an Iterated Inversion System (IIS). IIS allows us to perform calculation in parallel and render images fast. The speaker is developing an interactive visualization system using IIS. In this system, any generator is given by the inversion of a circle (or a sphere or a plane) or a composition of some inversions. Here it is important for us to observe and control these generators in a geometrical way. We can easily explore complicated groups including 4 dimensional Kleinian groups. This system will be helpful to researchers and also fractal artists. In this talk, we introduce the system and how to construct generators and apply it to IIS.

15:10 – 15:55 縫田 光司 (産業技術総合研究所)

トポロジーを暗号に応用したい

Recent studies of cryptography have interesting connections to many subjects of mathematics. In this talk, the speaker will introduce parts of such relationship between mathematics and cryptography, and would like to tell "dreams" about possible applications of topology to cryptography.

16:10 – 16:40 逆井 卓也 (東京大学)

An abelian quotient of the symplectic derivation Lie algebra of the free Lie algebra

We construct an abelian quotient of the symplectic derivation Lie algebra of the free Lie algebra generated by the fundamental representation of the symplectic group. More specifically, we show that the weight 12 part of the abelianization of the Lie algebra is stably 1-dimensional. The computation is done with the aid of computers. This is a joint work with Shigeyuki Morita and Masaaki Suzuki.

16:50 – 17:35 高山 (西) 晴子 (城西大学)

Polyhedral structures of the configuration space of points on P^1

Thurston showed that the moduli space of configurations of points on the complex projective line admits a family of hyperbolic metrics parameterized by sequences of real numbers (a_1, \dots, a_n) with $0 < a_i < 1$ summing up to two. Their metric completions are $(n - 3)$ -dimensional complex hyperbolic cone manifolds. In this talk, I will discuss the real part of these cone manifolds by relating them to the moduli space of Euclidean polygons and present their polyhedral structures. Moreover, I will present a GAP software tool which calculates their fundamental groups, homology groups, as well as further combinatorial data. This is joint work with J. Spreer.

10月30日 (日)

9:30 – 10:00 清水 理佳 (群馬工業高等専門学校)

Reductivity problem on knot projections

A knot projection on a 2-sphere is a regular immersion of a circle to the sphere. We say that a knot projection is reducible if we can draw a circle on the sphere which intersects the knot projection transversely at one crossing. Otherwise, we say that it is reduced. We consider a local move, called an inverse-half-twisted splice, which is a splice at a crossing such that the orientation of the knot projection is not preserved. We always obtain a knot projection (not a link projection) from a knot projection by this move. The reductivity of a knot projection is the minimum number of inverse-half-twisted splices needed to obtain a reducible knot projection from the knot projection. It is shown that the reductivity is four or less for any knot projection. However, it is unknown if there exists a knot projection with reductivity four. In this talk, we give an unavoidable set of parts for a knot projection with reductivity four (if exists) by considering 4-gons. This is a joint work with Yui Onoda.

10:10 – 10:55 Alden Walker (Center for Communication Research)

Rigorous mathematical certificates

I'll describe how we can actually compute the subgroup certificate from my "surface subgroups" talk and how this program fits into a much larger program designed to construct fatgraphs. I'll discuss another situation involving iterated function systems in which we can produce a certificate that a certain fractal is connected, allowing us to prove the existence of geometrically nontrivial components of Schottky space. If time permits, I'll give some more examples of rigorously experiments in pure math. Could involve work joint with Juliette Bavard, Danny Calegari, and Sarah Koch.

11:10 – 11:40 若月 駿 (東京大学)

Computation of string operations using rational homotopy theory

Let LM be the free loop space of a rational Gorenstein space M . Félix and Thomas defined string operations on the homology of LM . Using rational homotopy theory, we have an elementary description of these operations. In this talk, we discuss computations of string operations by this description.

11:50 – 12:35 和田昌昭 (大阪大学)

OPTi 4

OPTi is a program for visualizing quasi-conformal deformations of the once-punctured torus groups. I started working on the program in around 1996, so it is a 20-year-old project now. OPTi has been inspiring many researchers in hyperbolic geometry and Kleinian groups.

The first versions of OPTi ran on Macs with 680x0 cpu's and PowerPC. In 2005 Apple started transition from PowerPC to Intel processors, and in around 2009 they dropped support for PowerPC. The last OS version on which OPTi 3 runs was 10.6 for a long time. I knew mathematicians who kept their Mac from upgrading to newer OS just to run OPTi. After several years of preparation, I finally released OPTi 4 this May. I would like to talk about what it took me to update OPTi for the newest Mac OS X.