



UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

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HEGL PROSEMINAR / SEMINAR

GRAPHS ON HYPERBOLIC SPACES

This is the first iteration of the HEGL Seminar, the seminar of the newly founded **Heidelberg Experimental Geometry Lab (HEGL)**. This semester, the seminar will focus on hyperbolic geometry, graph embeddings, and their visualization.

Participation in this seminar includes:

- Giving a (shorter) mathematical talk,
- Working on a mathematical programming project in a small group,
- Giving a presentation on the project.

Short Introduction:

Hyperbolic geometry is the star of non-Euclidean geometries. It occurs in a perfect “world” of constant negative curvature. It is a very active field of mathematical research and it can be useful in other sciences, including data science and machine learning.

Graphs are fundamental structures in mathematics and computer science that have countless applications in other fields such as biology, chemistry, economy, linguistics, etc. It is often useful to embed graphs in the Euclidean plane or in higher-dimensional spaces to visualize them and study their properties. One of the goals of this seminar is to investigate graph embeddings in hyperbolic spaces, both theoretically and experimentally.

Schedule of the semester:

- Week 15: Getting started with Python
- Weeks 16–18: Math talks (3 talks per session)
- Weeks 19–24: Work on projects
- Week 22: Short updates on projects
- Weeks 25–28: Final presentation of projects

The participants will be divided in groups of three (approximately). Each group will do a Math talk session (consisting of three individual talks) and one Project presentation.

Seminar location and time:

Meeting on Wednesday, April 7, 2021 at 2pm to assign topics and discuss details.

We plan to meet weekly on Wednesday, 2-4pm.

(More information will be sent to the interested students by email (so enroll early).)

Intended audience and prerequisites:

The intended audience is mainly Bachelor students, possibly Master students. Some background in programming is helpful but not required. Furthermore, we require familiarity with groups and ideally also with geometry.

The seminar will be in English.

Enroll in the seminar:

If you are interested in this seminar, contact Brice (bloustau@mathi.uni-heidelberg.de) or Anja (arandecker@mathi.uni-heidelberg.de) **before April 6.**

List of topics:

Topic A: Hyperbolic geometry I

Math talks: The math talks will give an introduction to the main concepts of hyperbolic geometry, in particular the Poincaré disk models and the Klein model of the hyperbolic plane.

Project: How to visualize the hyperbolic plane? The project will introduce tools to navigate the hyperbolic plane in different models.

Topic B: Hyperbolic geometry II

Math talk: The math talks should present isometries of the hyperbolic plane: their description in different models, their classification, etc. The end goal should be the presentation of tessellations (or tilings) of the hyperbolic plane.

Project: The project will consist in generating beautiful tessellations of the hyperbolic plane, and print posters to decorate the HEGL room.

Topic C: Graph theory

Math talk: The math talks should present the general theory of graphs (and maybe simplicial complexes), including planar graphs, topology of graphs, and graphs on surfaces.

Project: The project will consist in implementing various graph structures in Python (or another programming language) and being able to generate embeddings of such graphs in the Euclidean plane, the hyperbolic plane, and possibly other surfaces.

Topic D: Graphs and data

Math talk: The math talks should give a short presentation of data science, machine learning, and the use of graphs (and maybe hyperbolic geometry) in these subjects.

Project: The project will consist in collecting real-world data, storing it into graph structures, and using geometric embeddings in order to study the data.