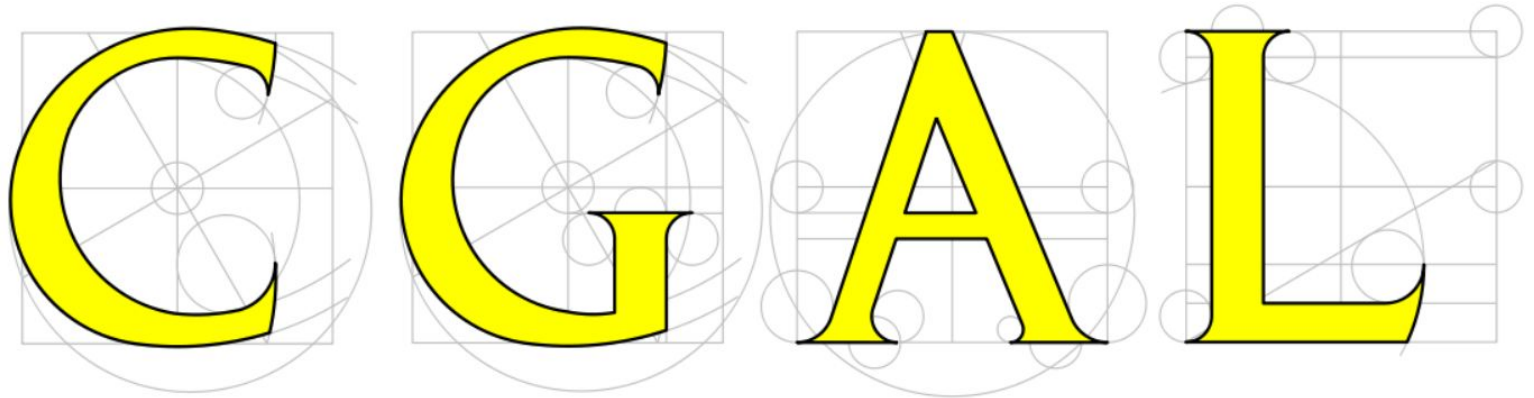
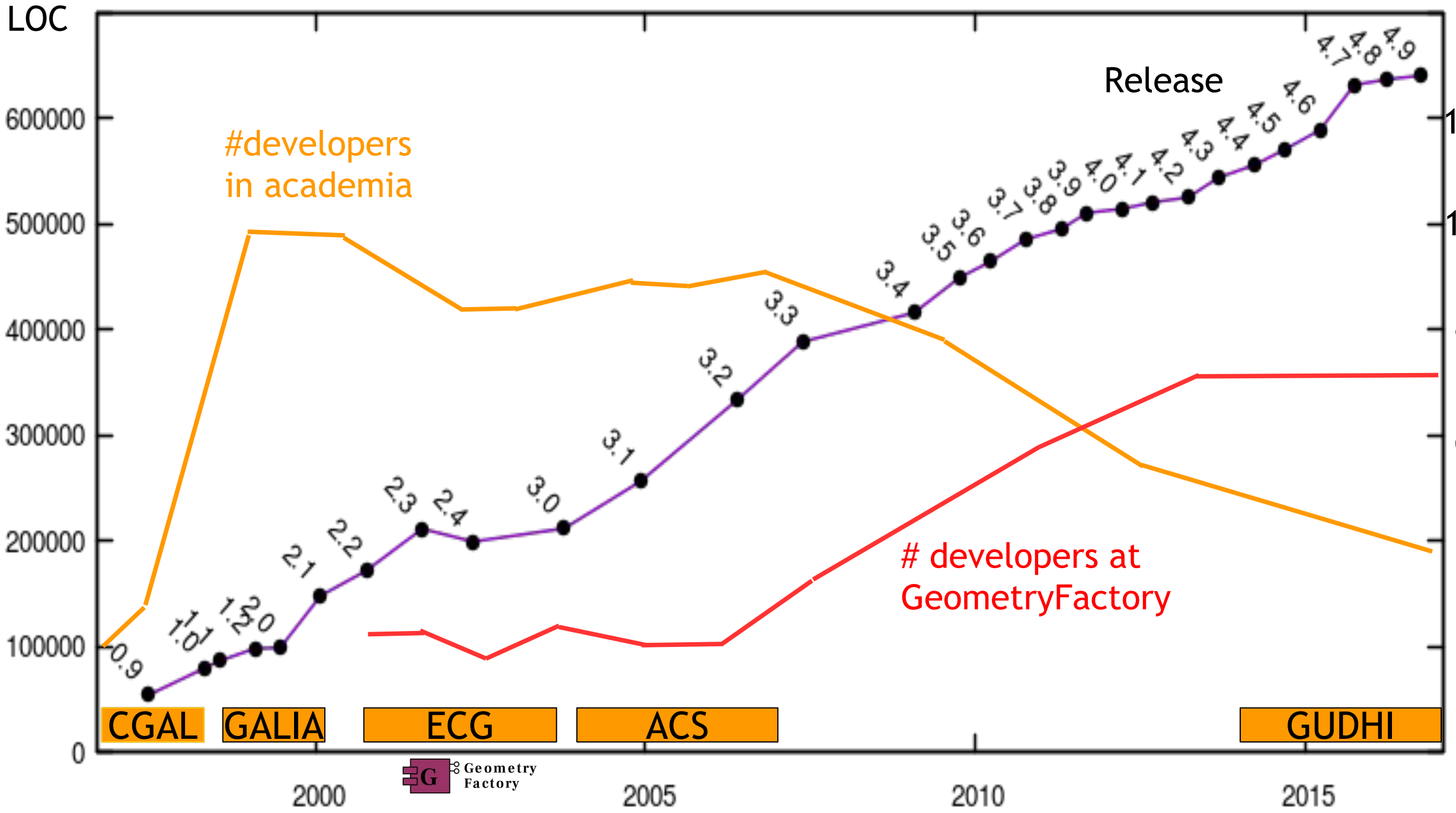


Computational Geometry Algorithms Library

GeometryFactory – A Company that Emanated from an Open Source Project

Geometry Factory

Andreas Fabri


LOC
Release
#developers
in academia
developers at
GeometryFactory
CGAL
GALIA
ECG
ACS
GUDHI
Geometry
Factory
0
100000
200000
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0.9
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3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9

Overview

- The CGAL Project
- GeometryFactory
- The Market
- R&D at GeometryFactory
- Interaction with Academia

The CGAL Project

Mission Statement

"Make the large body of geometric algorithms developed in the field of computational geometry available for industrial applications"

CGAL EU Project Proposal, 1996

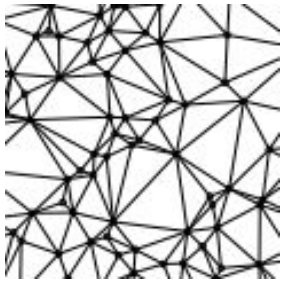
Project = « Planned Undertaking »

- Academic partners make a long term commitment:
- INRIA, Max-Planck Institute, Tel-Aviv U, ETH Zurich, Utrecht University, ...

- CGAL Editorial Board
  - Steers and animates the project
  - Reviews submissions

- Development infrastructure
  - github, travis, nightly test suite (~30 configurations in Docker)
  - Two 1-week developer meetings per year

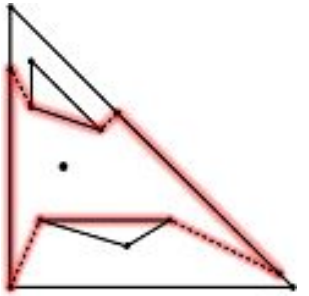
CGAL 2D Algorithms and Data Structures



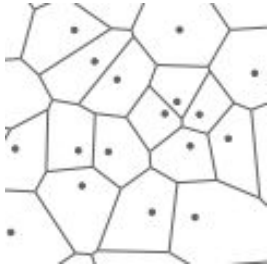
Triangulations

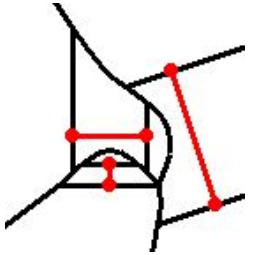
2D Mesh Generation

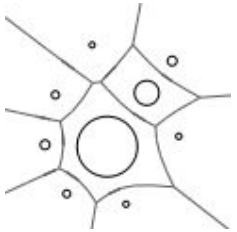
Polyline Simplification



Visibility

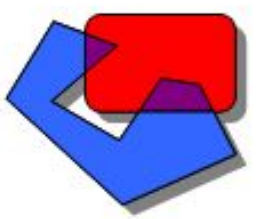


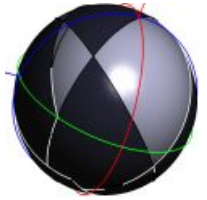




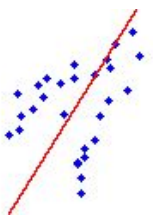
Voronoi Diagrams

Arrangement

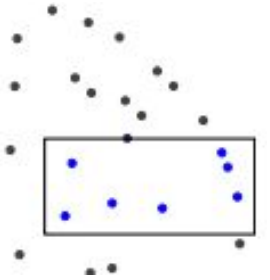




Boolean Operations

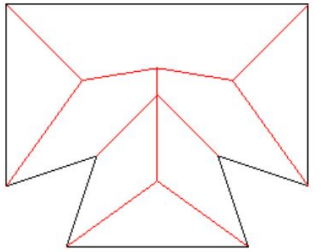


PCA



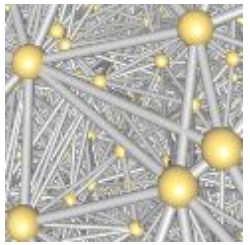
Neighb
or
Search

Minkowski
Sum



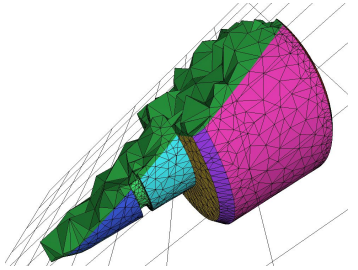
Straight
Skeleton

CGAL 3D Algorithms and Data Structures



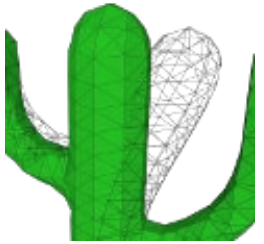
Triangulations
Voronoi Diagrams

Polyhedral Surface

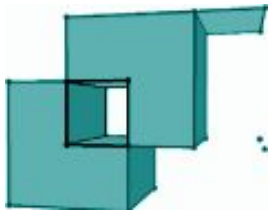


Mesh Generation

Parameterization

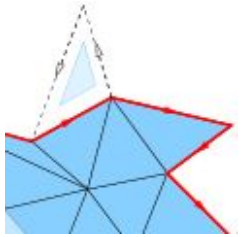


Deformation



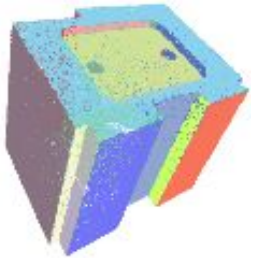
Boolean Operations

Convex Hull

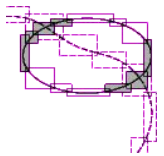


Surface
Reconstruc
tion

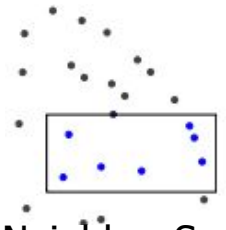
Simplification



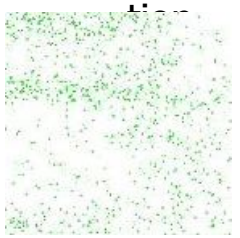
Classification



Intersection
Detection



Neighbor Search



Point Set Processing

Segmentation

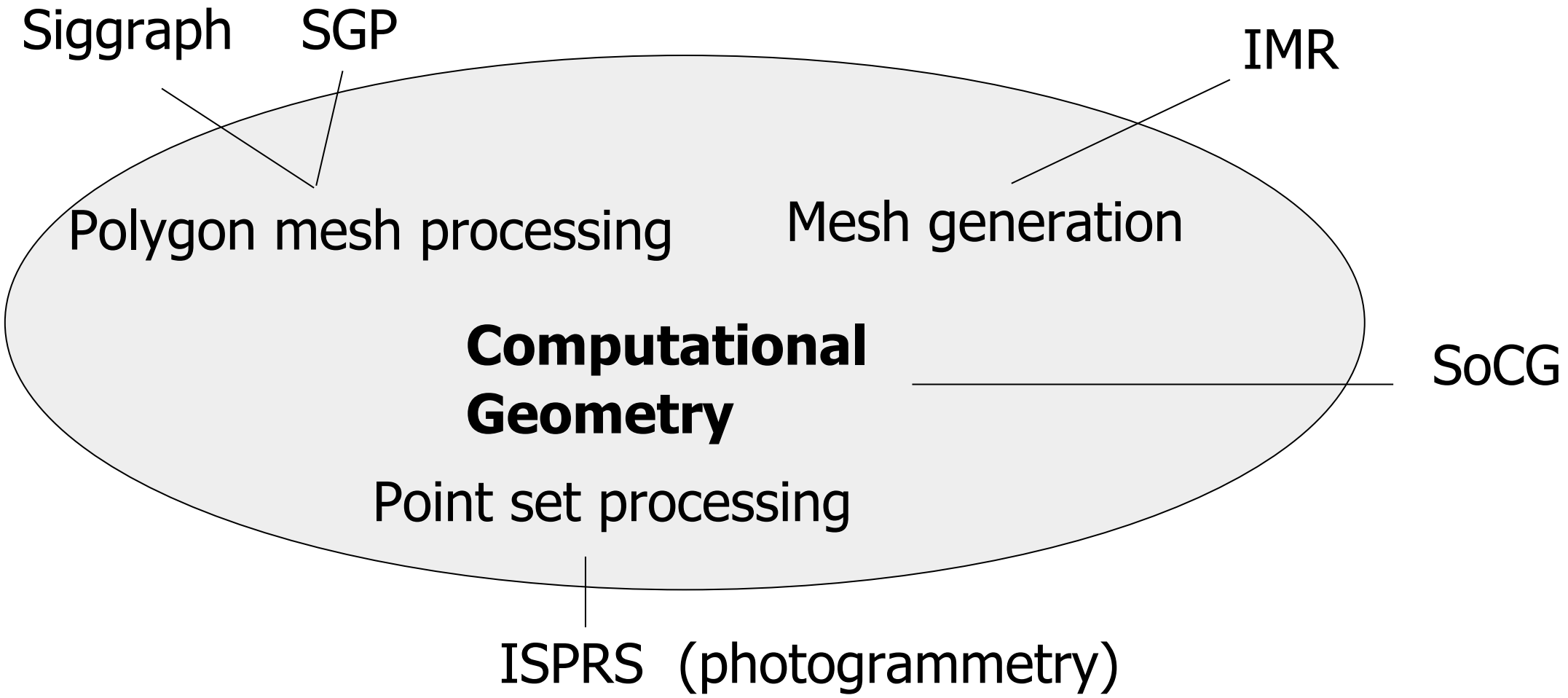
Skeletonization

Research Topics

- Algorithm design
  - Robustness when dealing with floating point numbers
  - Correctness (convergence, guaranteed quality of mesh elements)
  - Performance (in O() notation as well as in practice)

- Software design
  - Make it easy to adapt and to integrate
  - Development of generic code (C++ templates as in STL, boost)

Towards a Geometric Computing Library



CGAL in Numbers

600,000	lines of C++ code
10,000	downloads/year (+ Linux distributions)
3,500	manual pages (user and reference manual)
1,000	subscribers to user mailing list
120	software components
200	commercial users
20	active developers
6	months release cycle
2	licenses: Open Source and commercial

GeometryFactory

GeometryFactory

- 6 PhDs + 1 MSc in CS with focus on geometric computing
- No sales and marketing people

- Development of CGAL software components
- Maintenance and industrialization of
  CGAL software components and research prototypes

- Sales of CGAL licenses (business to business)
- Sales of support services to increase customer productivity

Commercial Licence Sales

- One-time fee, perpetual, royalty free *per CGAL component*
- Annual Research License *for entire CGAL library*

- Remarks
  - Illusion of *unique selling proposition* with the library.
  - The library is not the product, but crucial for the perception
  - Licensing is possible due to agreements with the Institutes
  - The last years GeometryFactory payed royalties of ~100KEuro

Pricing

- One-time fee, not per developer, perpetual, royalty free
- What is the right price?
- If it is “too expensive – we are a start-up”,
  do not offer reduction but instalments (pay ¼ over 3 years)
- Royalty based license fee would be interesting, but
  - hard to impose as published + open source
  - sometimes seeked by app-developers without money

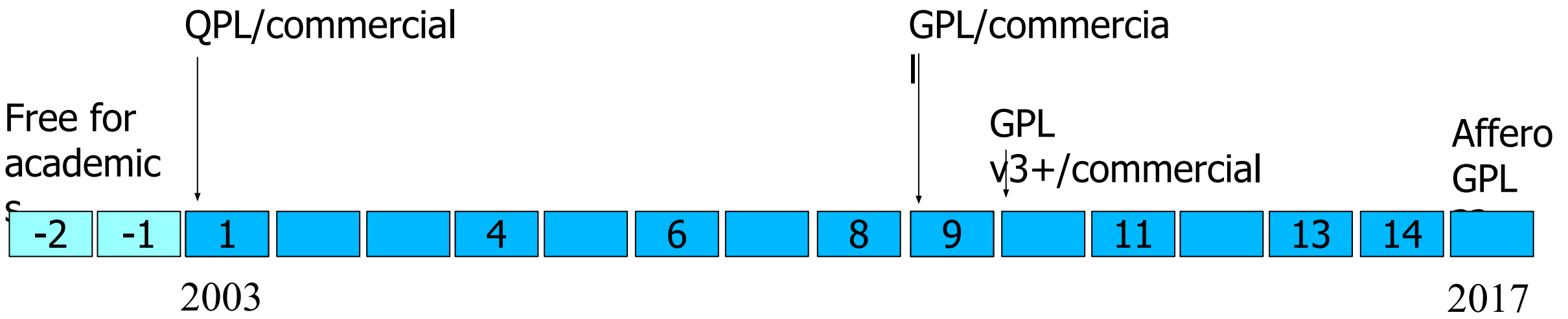
Services: Support to Increase Productivity

- Training and consulting
- Customer specific development

- Dedicated shared workspace (confidentiality is important)
  - Issue tracker
  - Discussion forum (instead of mails)
  - git server for distribution of fixes (instead of attachments)

git

Open Source License



- Choice of license must be part of your strategy
- Qt did QPL → LGPL → GPL
- With a BSD style license CGAL would not exist
- With a BSD style license GeometryFactory would not exist

Protection of Intellectual Property

- No patents
- Inria registers at APP - Agence pour la Protection des Programmes
- Scientific publications

- Open Source license tradeoff
  - Illegal users and copy cats
  - Viral marketing
  - Get contributions (was a hope, which did not work out)

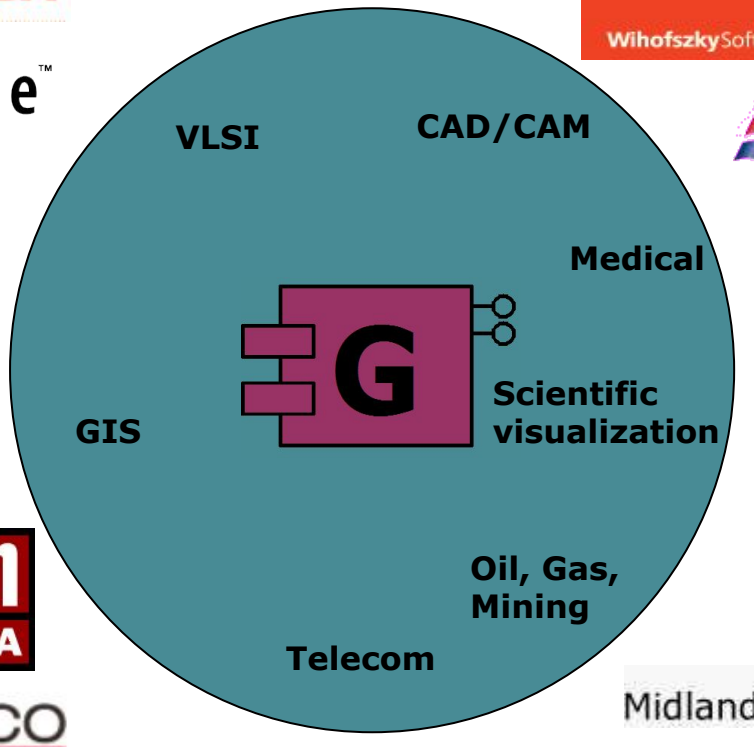
The Market

Horizontal and Vertical Market

- A *horizontal market* is a market in which a product or service meets a specific need of a wide range of buyers across different sectors of an economy.

- A *vertical market* is a market in which vendors offer goods and services specific to an industry, trade, profession, or other group of customers with specialized needs.

Some Commercial CGAL Users



SAMSUNG
Orbotech
pulsic
protomold
Autodesk
Exa CORPORATION
CMET シーメット株式会社
TOSHIBA
Wihofszky Software
MPC THEMOVINGPICTURECOMPANY
cadence
ECL
Agilent Technologies
schaerermayfield WHEREVER YOU OPERATE
GE Healthcare
TOMTEC IMAGING SYSTEMS
BAE SYSTEMS
ST. JUDE MEDICAL
QinetiQ
PRESAGIS
erdas
Virtualwind
School of Biomedical Sciences Exellence in Teaching 5* Research
INDUSTRIAL RESEARCH LIMITED
The MathWorks
SAFE SOFTWARE
rm DATA
PASCO World's Leading Geospatial Group
Midland Valley
roxar
Agip
TOTAL
Schlumberger
ESRI
TruePosition
orange
BR PETROBRAS
ارامكو السعودية Saudi Aramco
Trimble
ENVITIA
BT
RioTinto
brgm Géosciences pour une Terre durable
ExxonMobil

Some Commercial CGAL Users

Selling on a Horizontal Market

- Horizontal vs vertical was THE discussion with *InriaTransfert*

- We do what we can do best and what we like most
- We had not identified a killer application for an industry

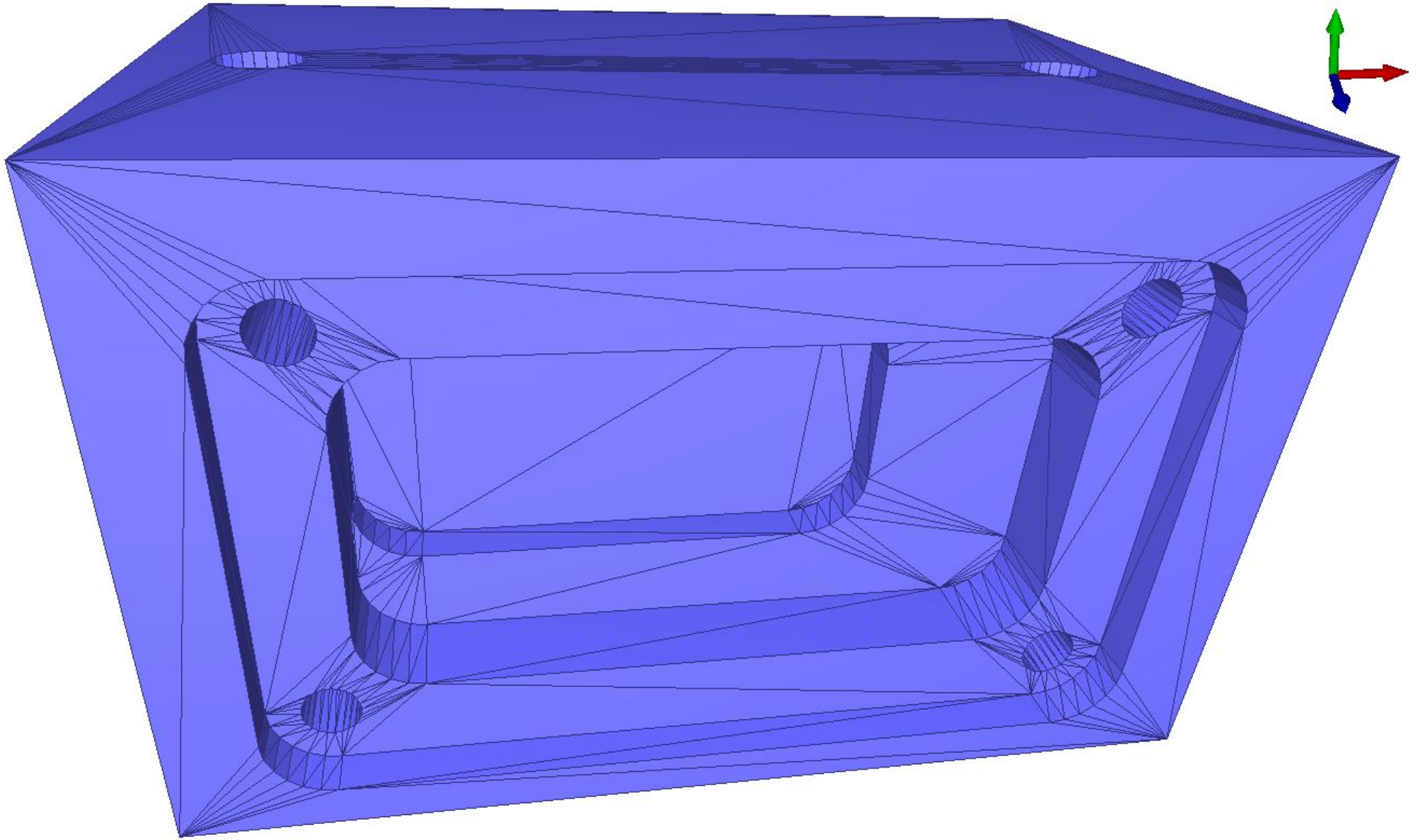
- Averages upturns/downturns in economic sectors and regions

- Expansion strategy
  - Broaden the base with academic partners
  - Offer bindings and plugins for platforms (swig, Paraview, Unity,..)

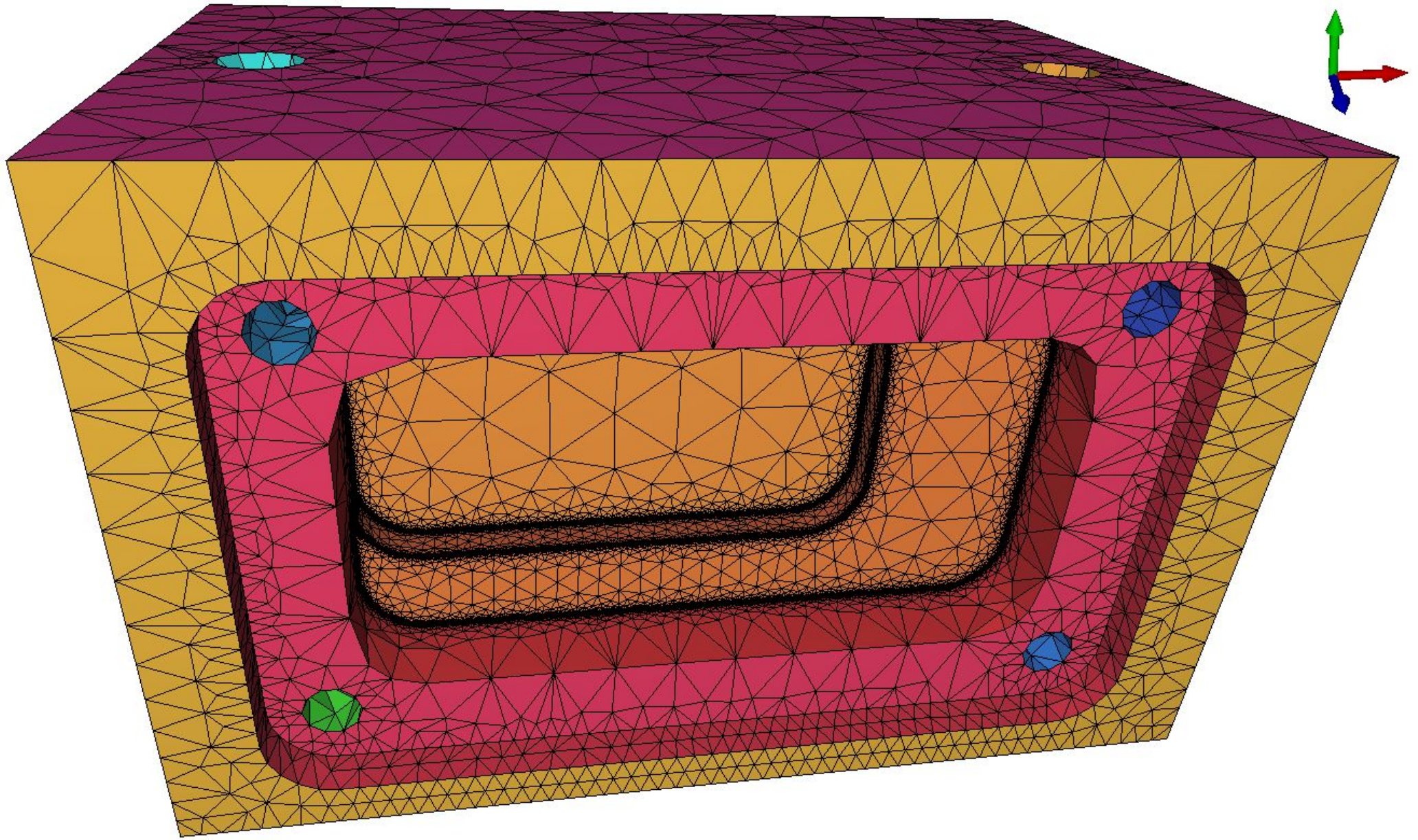
We Are Not the Only Ones

R&D at GeometryFactory

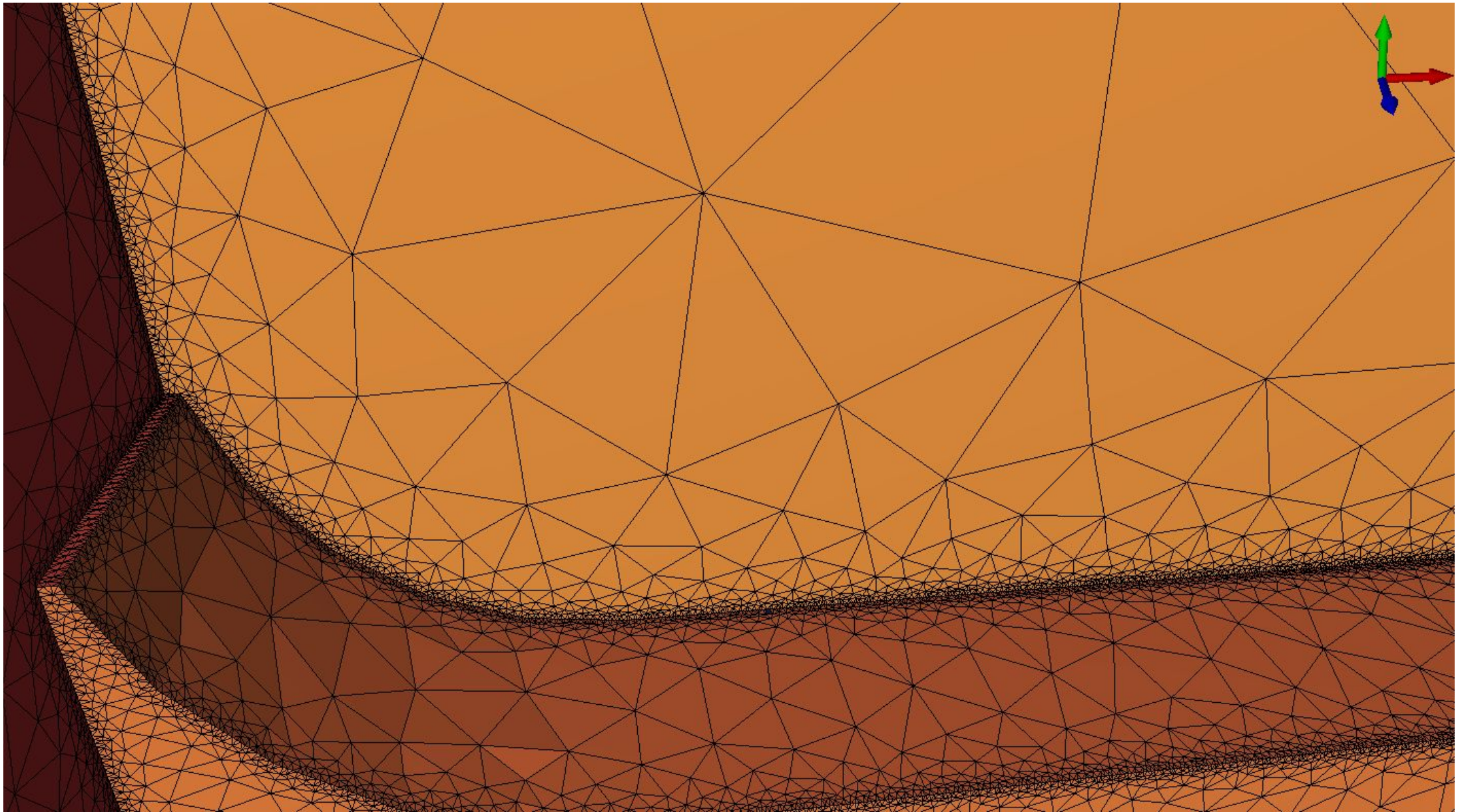
Industrialization of the Tetrahedral Mesh Generator



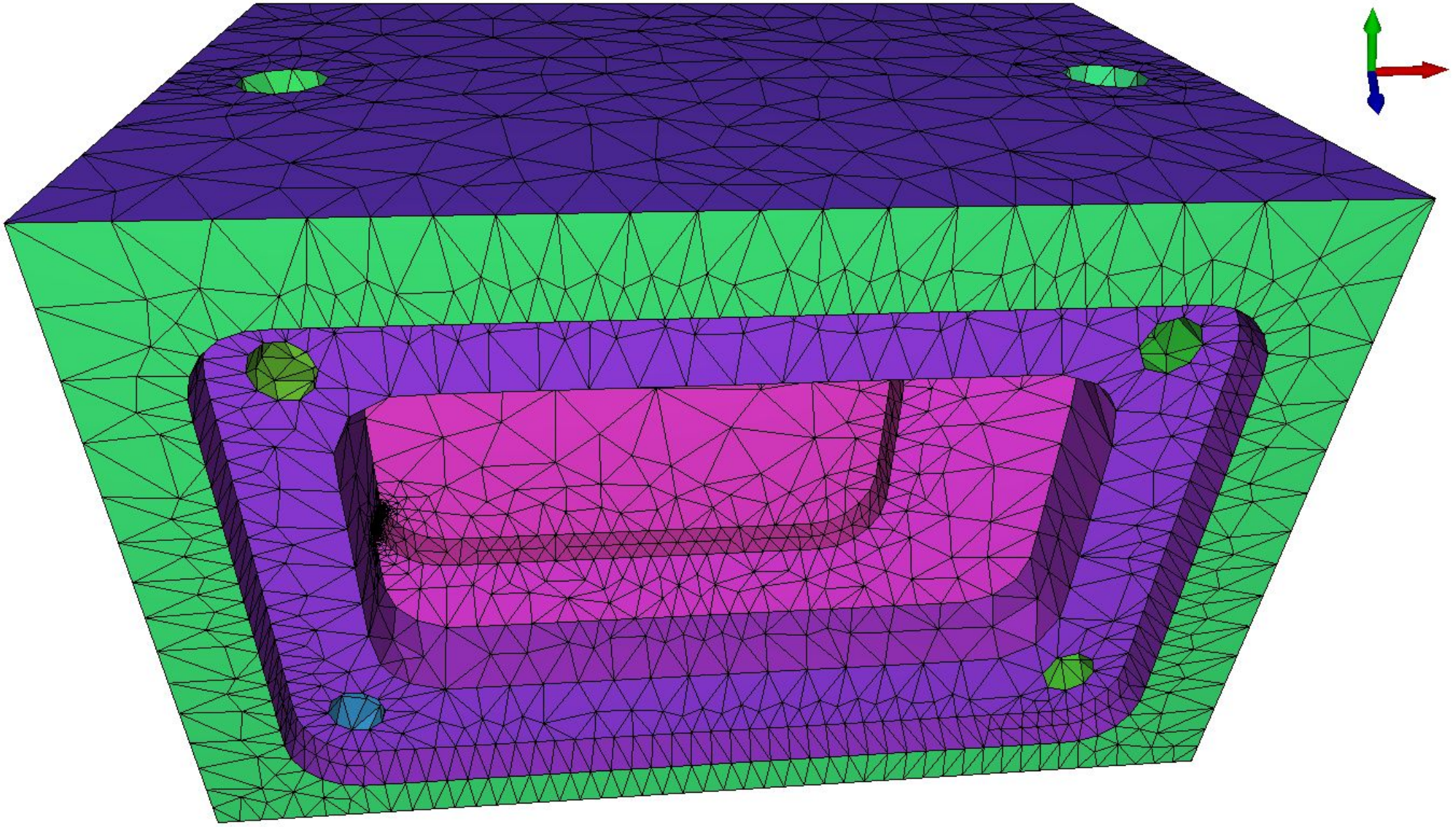
Industrialization of the Tetrahedral Mesh Generator



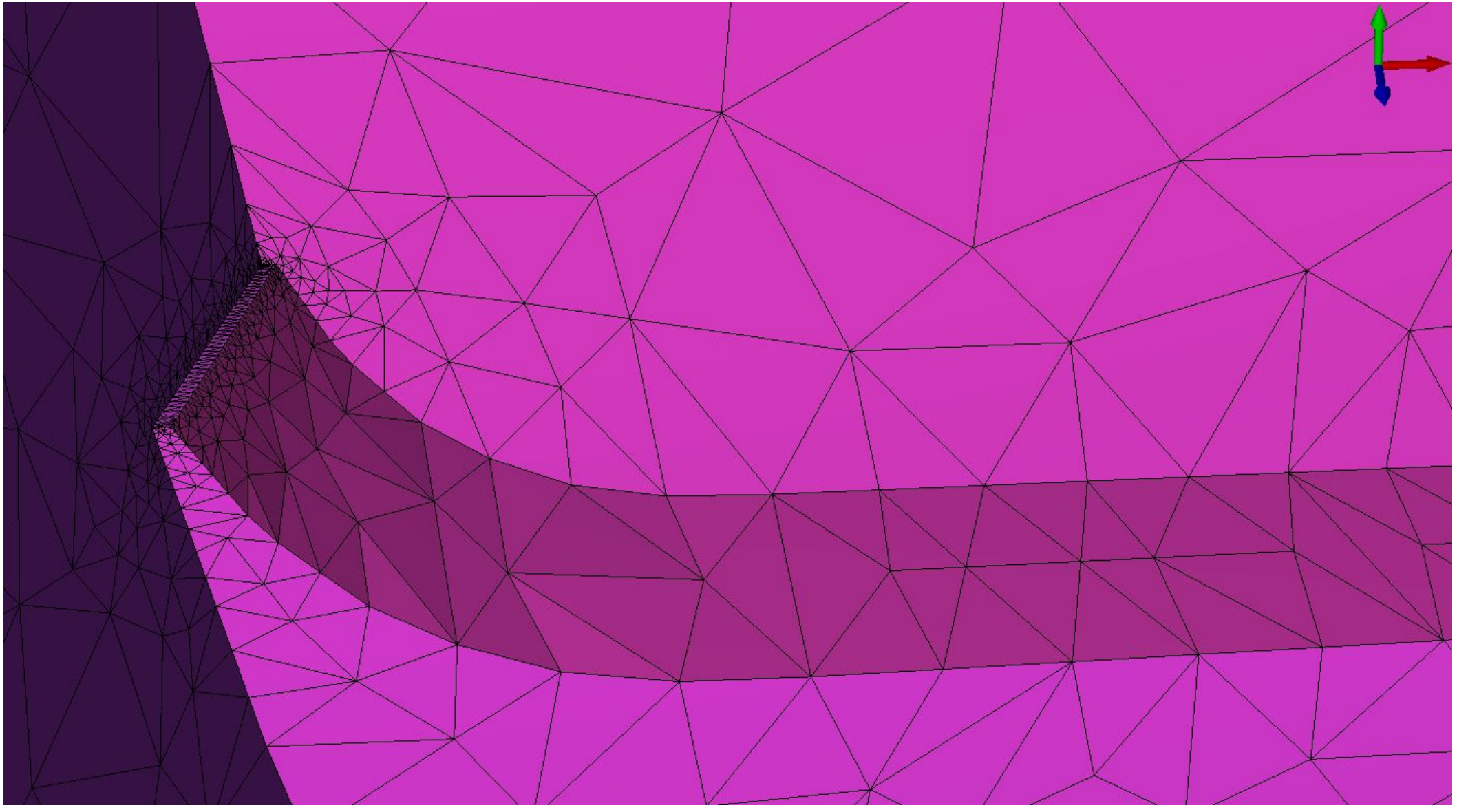
Industrialization of the Tetrahedral Mesh Generator



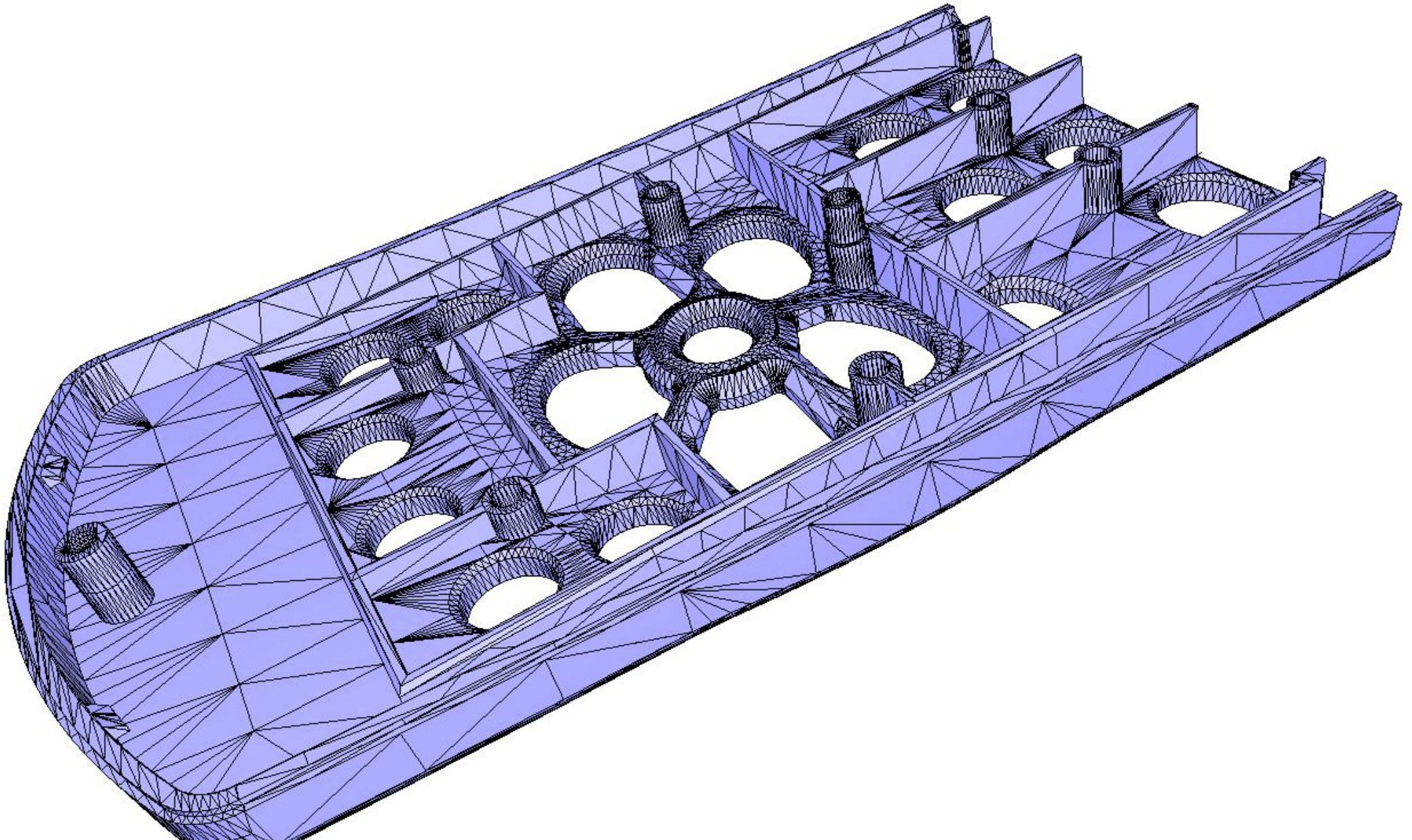
Industrialization of the Tetrahedral Mesh Generator



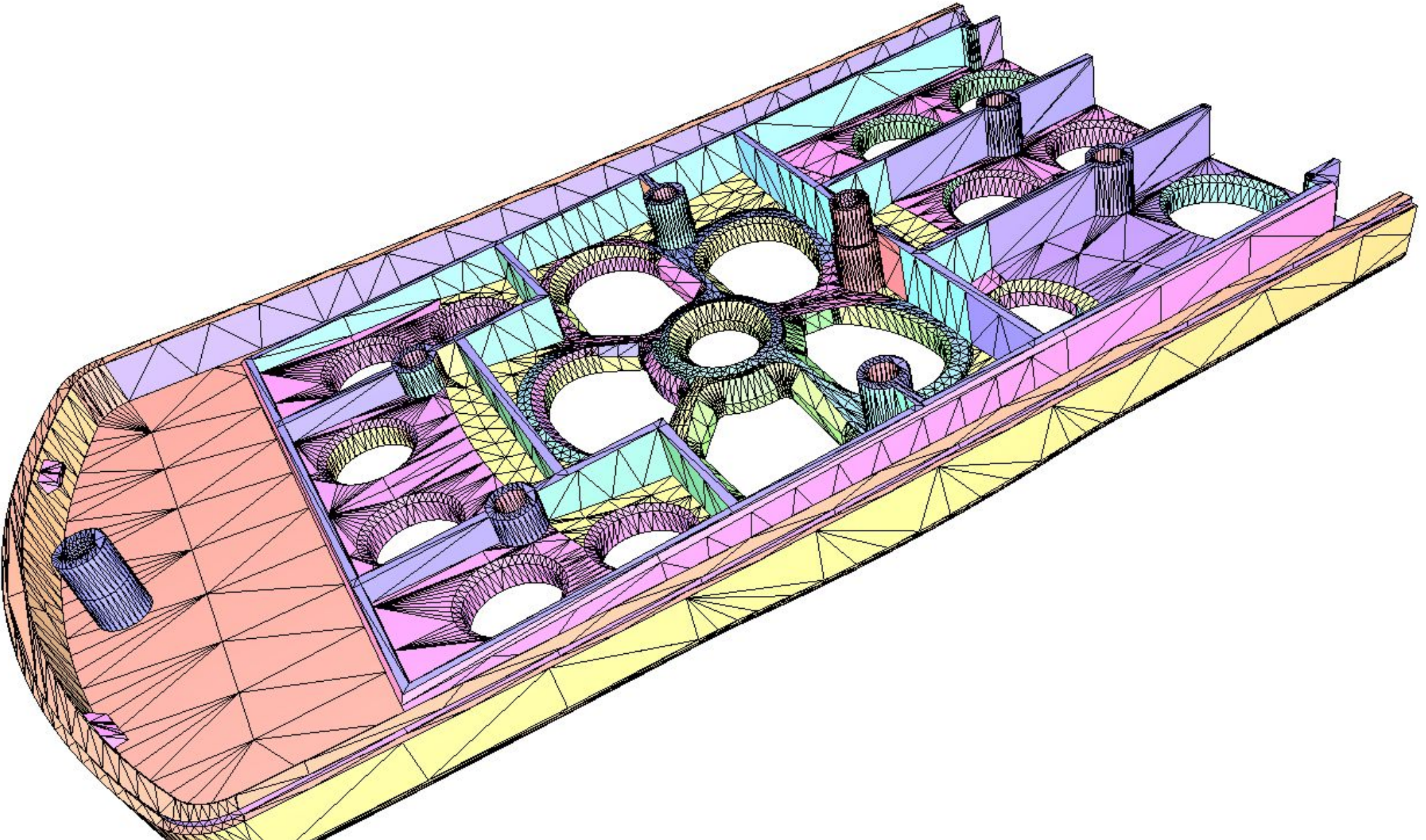
Industrialization of the Tetrahedral Mesh Generator



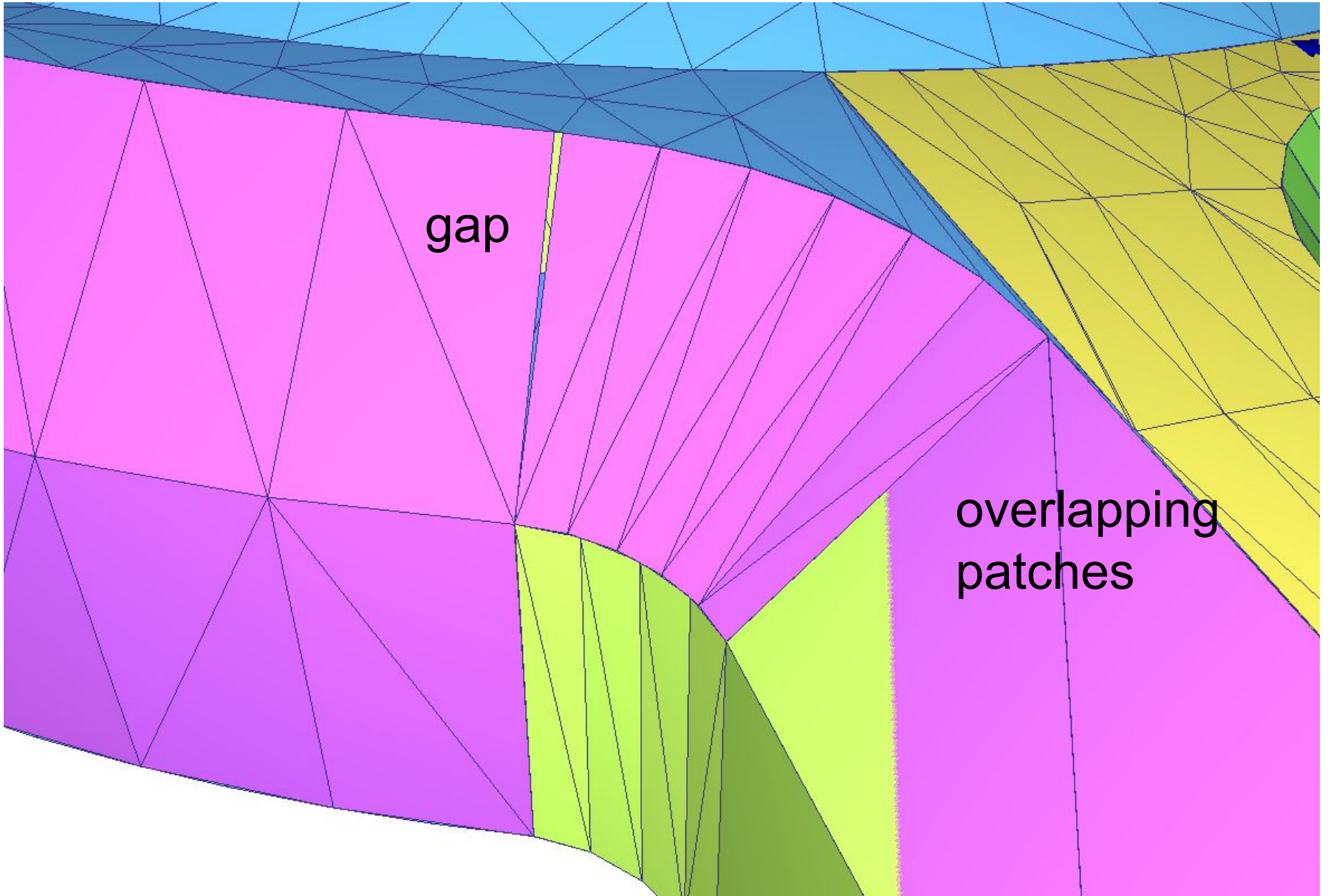
Mesh Repair



Mesh Repair

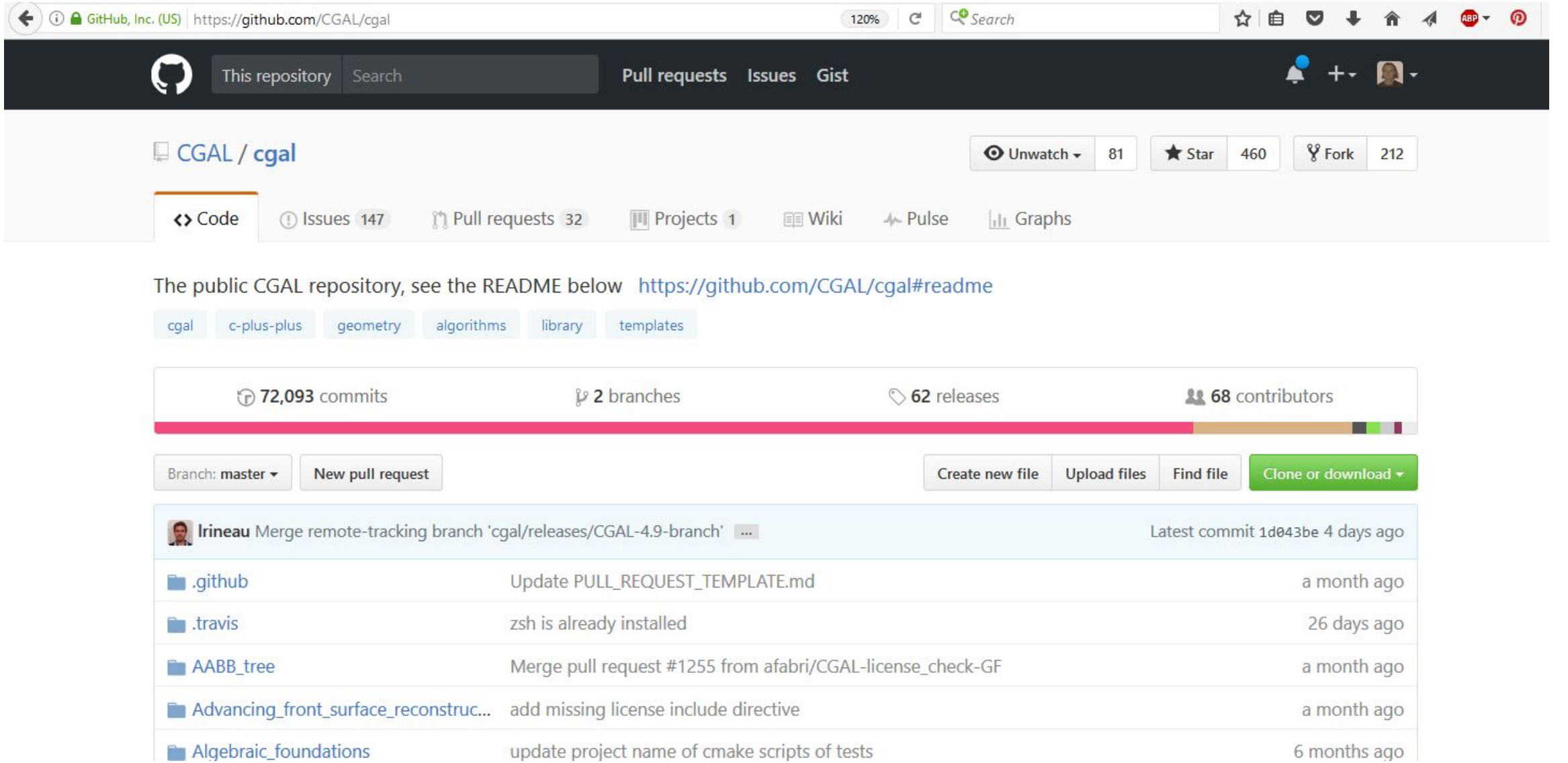


Mesh Repair

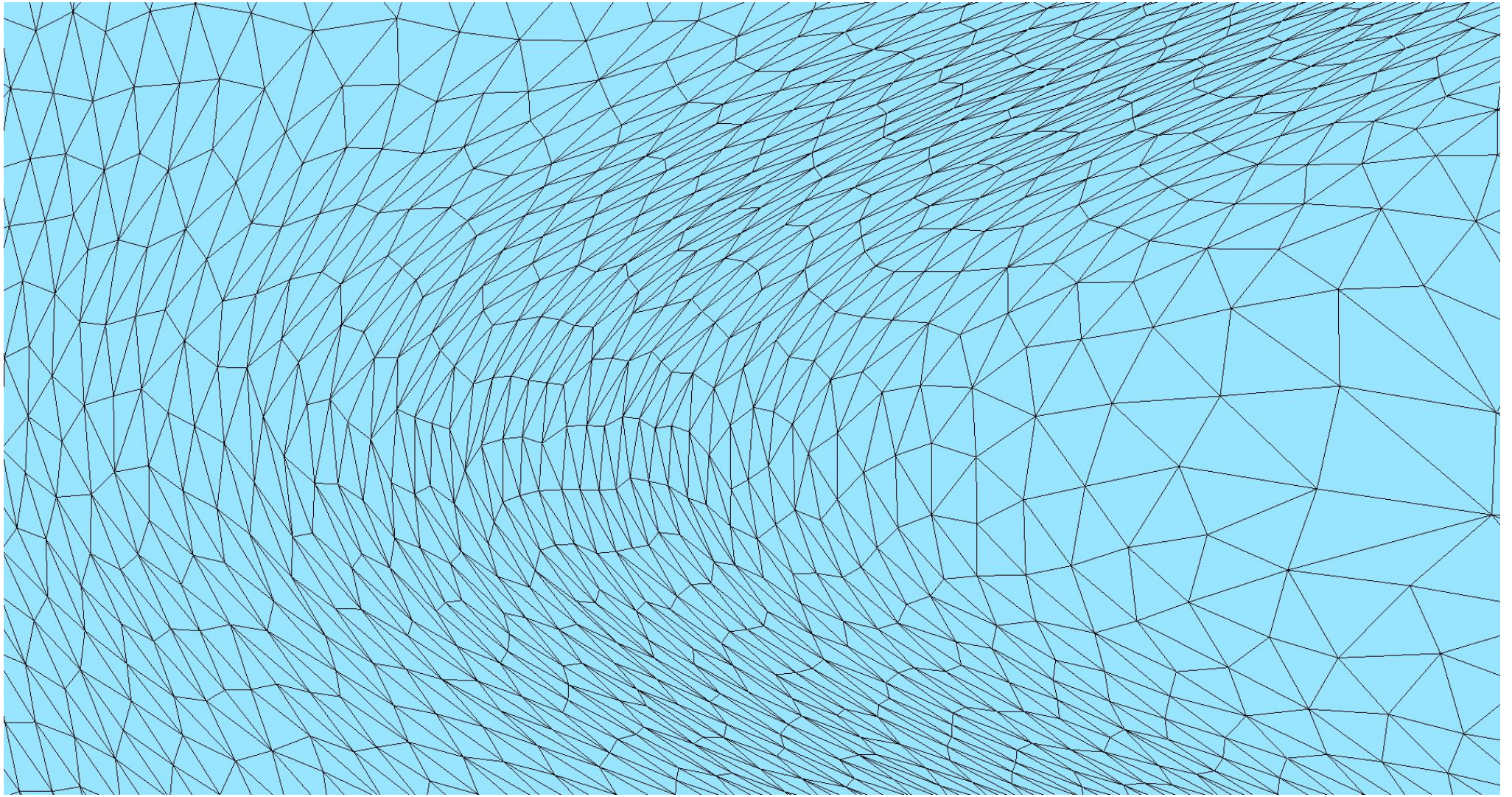


Interaction with Academia

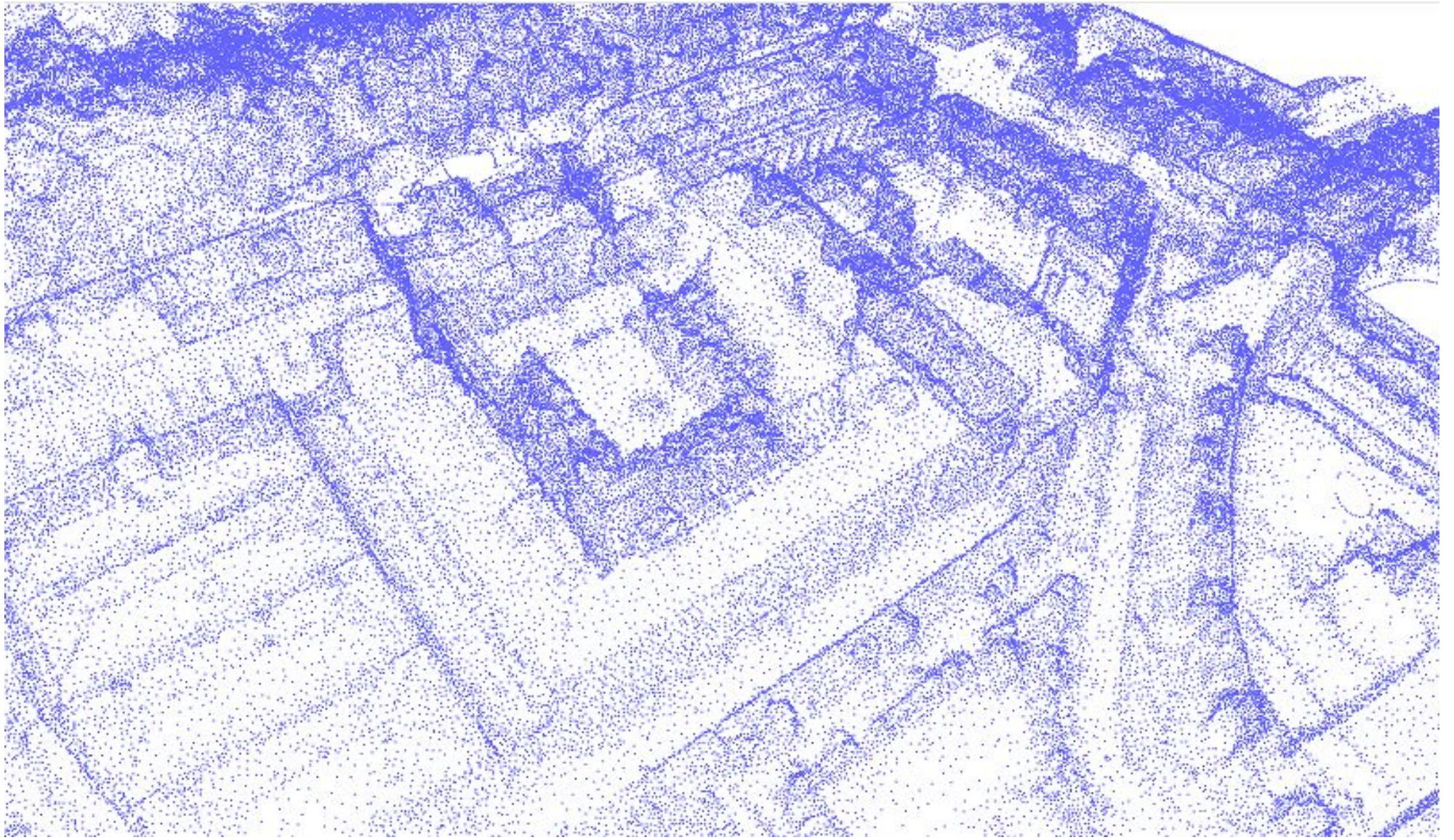
CGAL Project on github



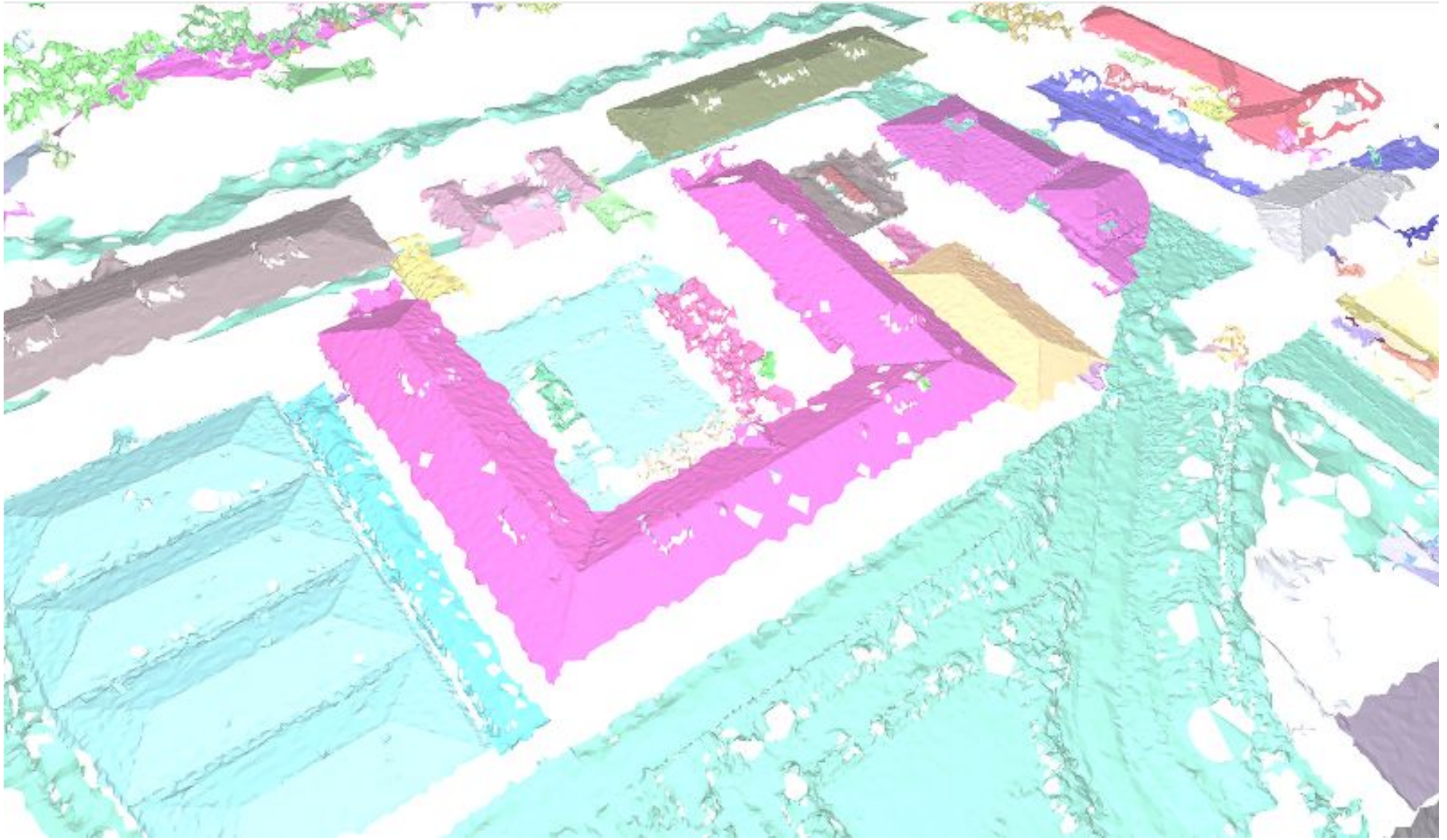
Anisotropic Remeshing (Thèse CIFRE, Geometrica)



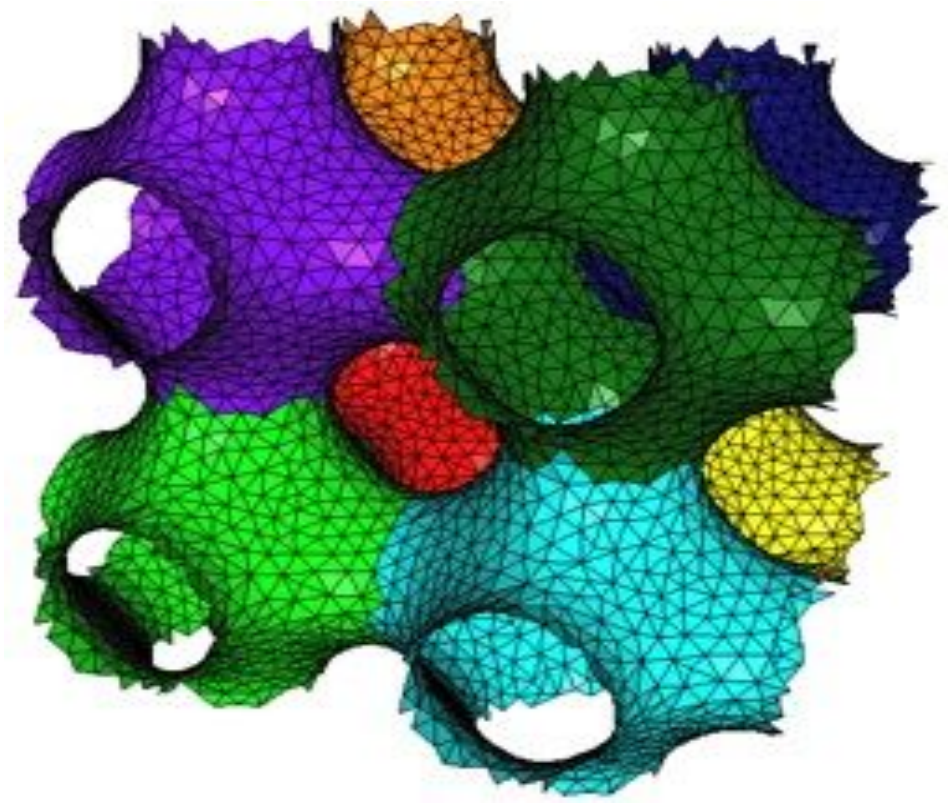
Point Set Classification (POC after ERC, Titane)

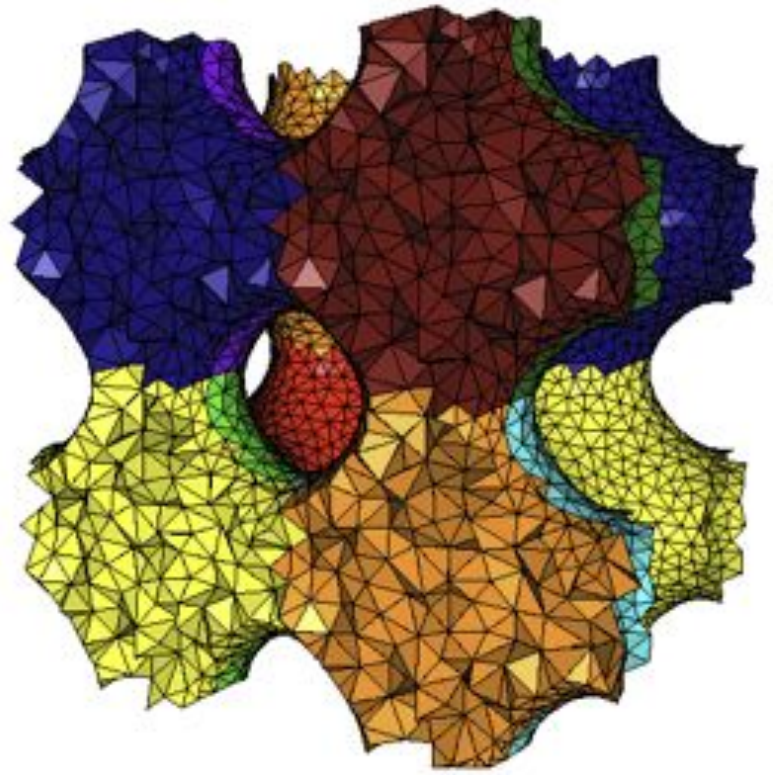


Point Set Classification (POC after ERC, Titane)



Finalisation of Periodic Mesh Generation (Gamble-LORIA)





Develop submodule for Quadmesher (RWTH Aachen)

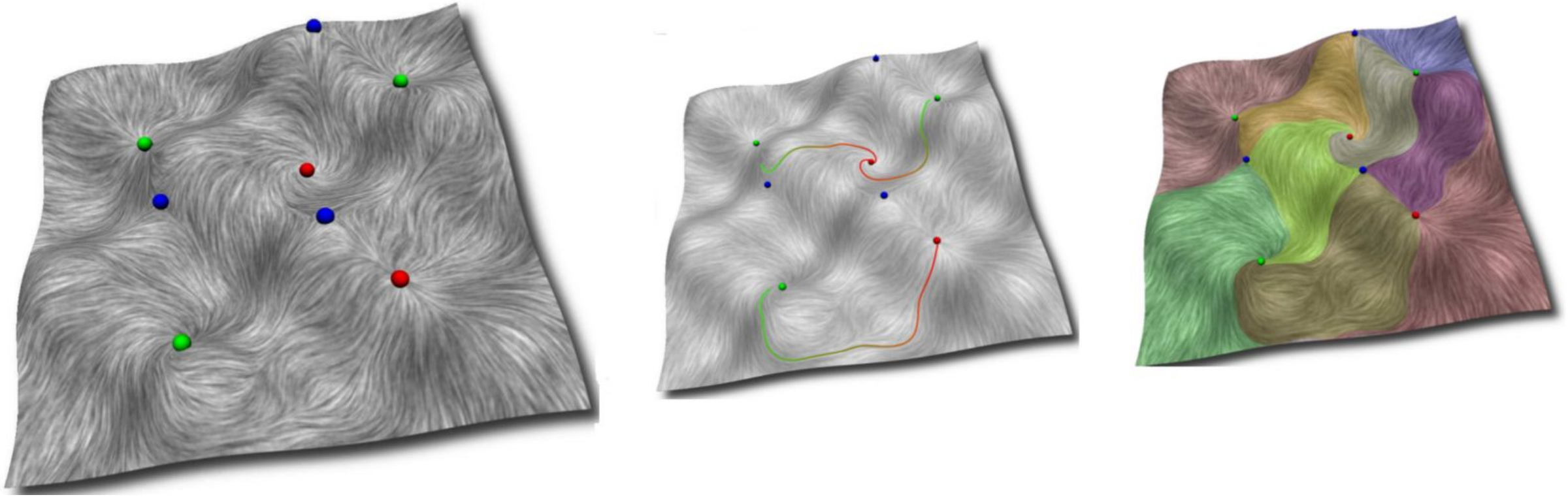
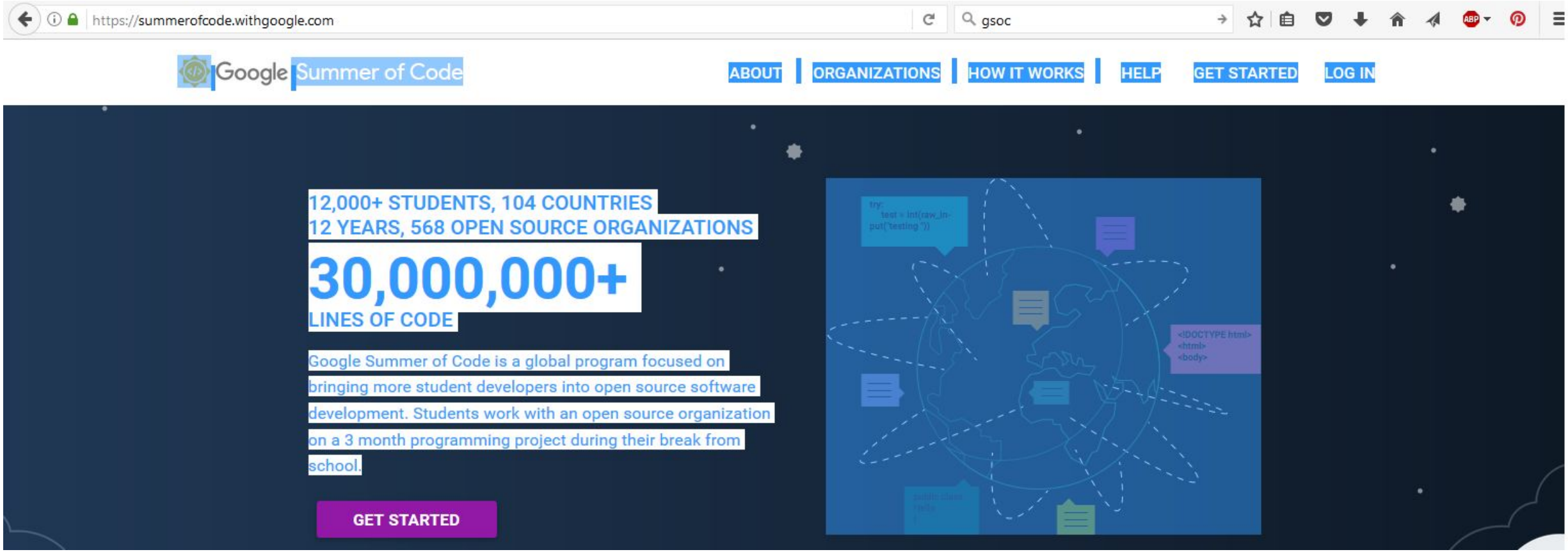


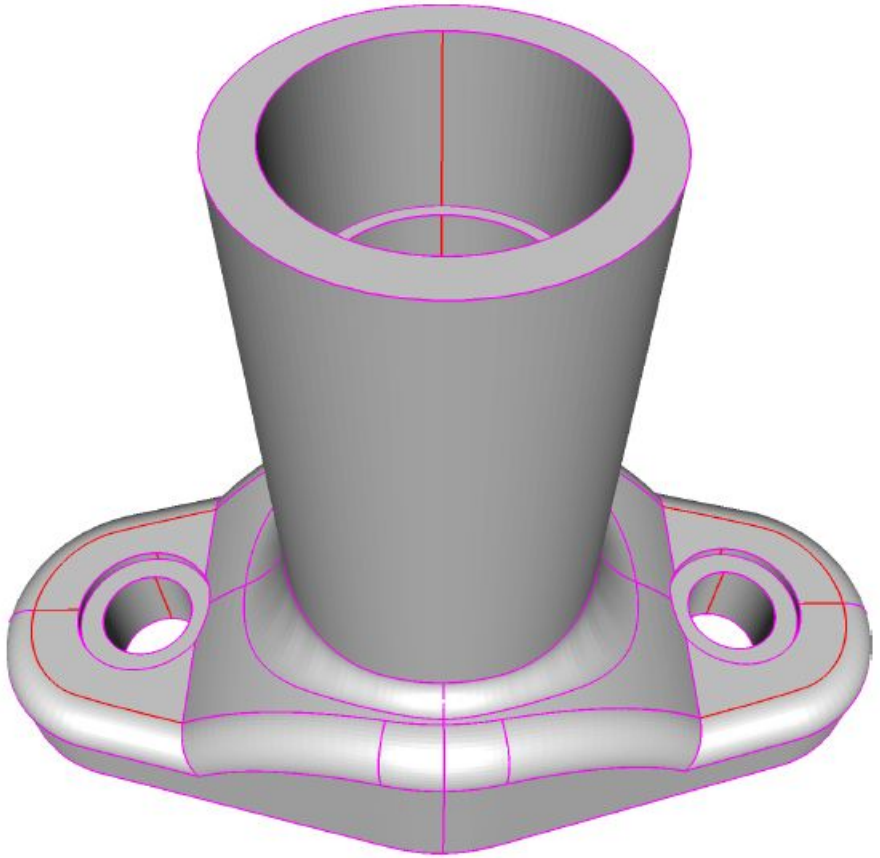
Image: Bathia&al.

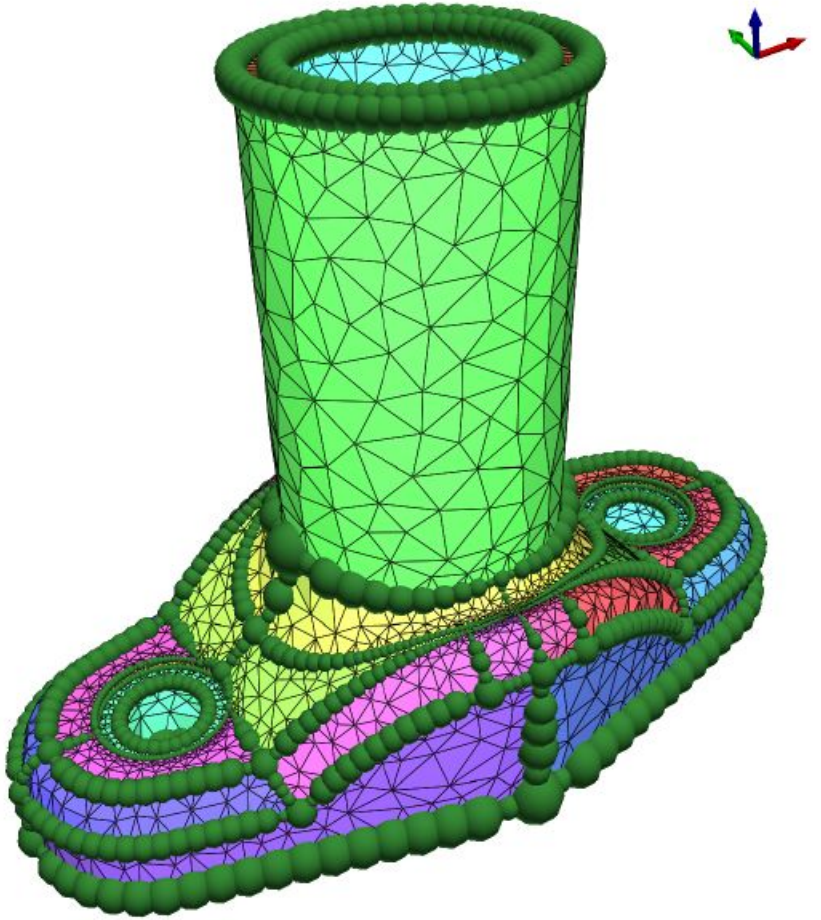
CGAL @ Google Summer of Code 2017



3 month projects: co-mentored by academic partner and GeometryFactory

Nurbs Meshing (DGT-T/Carnot for GF/Aromath/Titane)

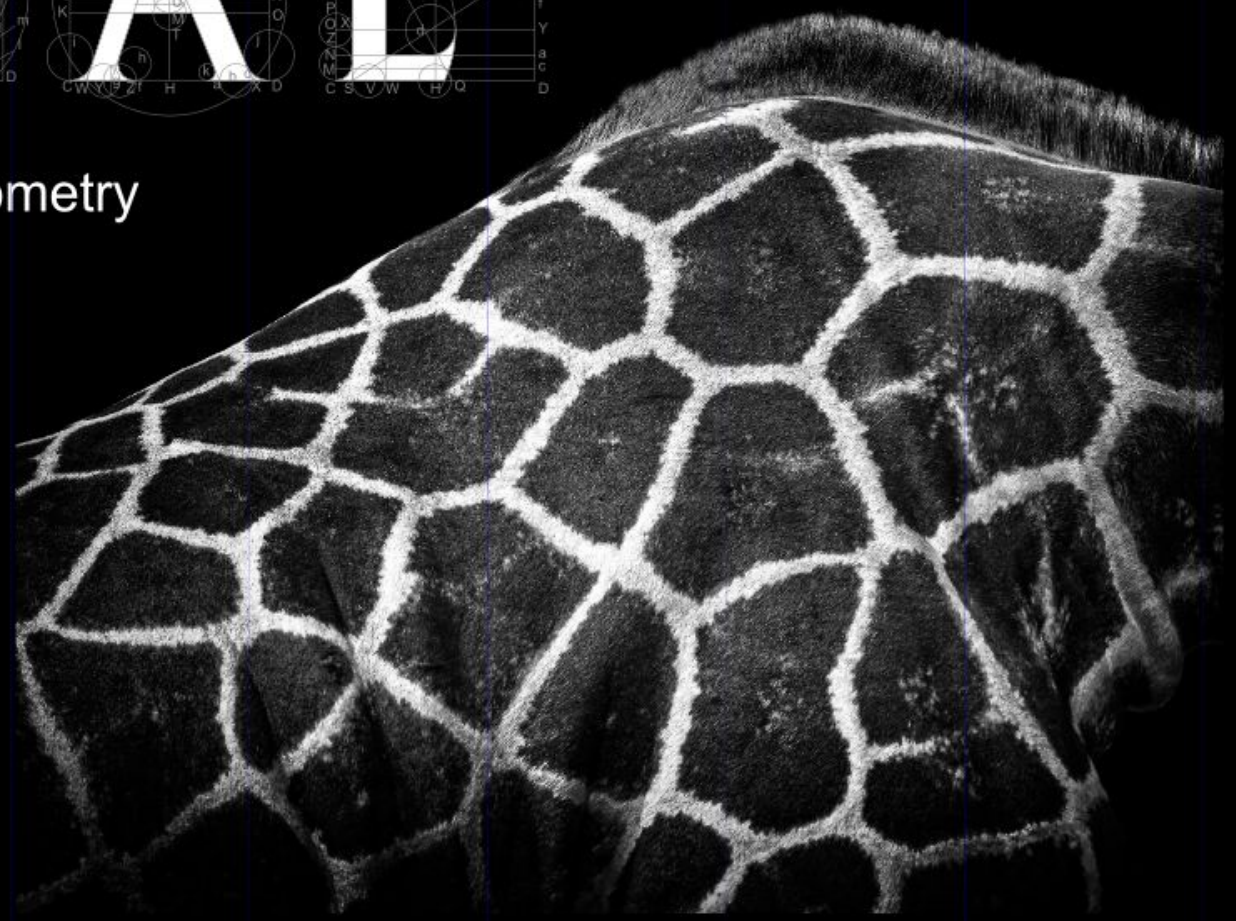




Open Position: 1 year at SED (Service Expérimentation et Développement)

CGAL

Computational Geometry
Algorithms Library



C++ Software Components
Rich APIs
Robust, Fast, Flexible

Windows / Linux / MacOS X

Open Source / Commercial

www.cgal.org

Constrained Delaunay Triangulation
Voronoi Diagrams
Boolean Operations
AABB Tree
Straight Skeleton
Alpha Shapes
KD Tree
Tetrahedral Mesh Generation
Arrangements
Surface Reconstruction
Point Cloud Processing
Mesh Simplification / Segmentation / Deformation