

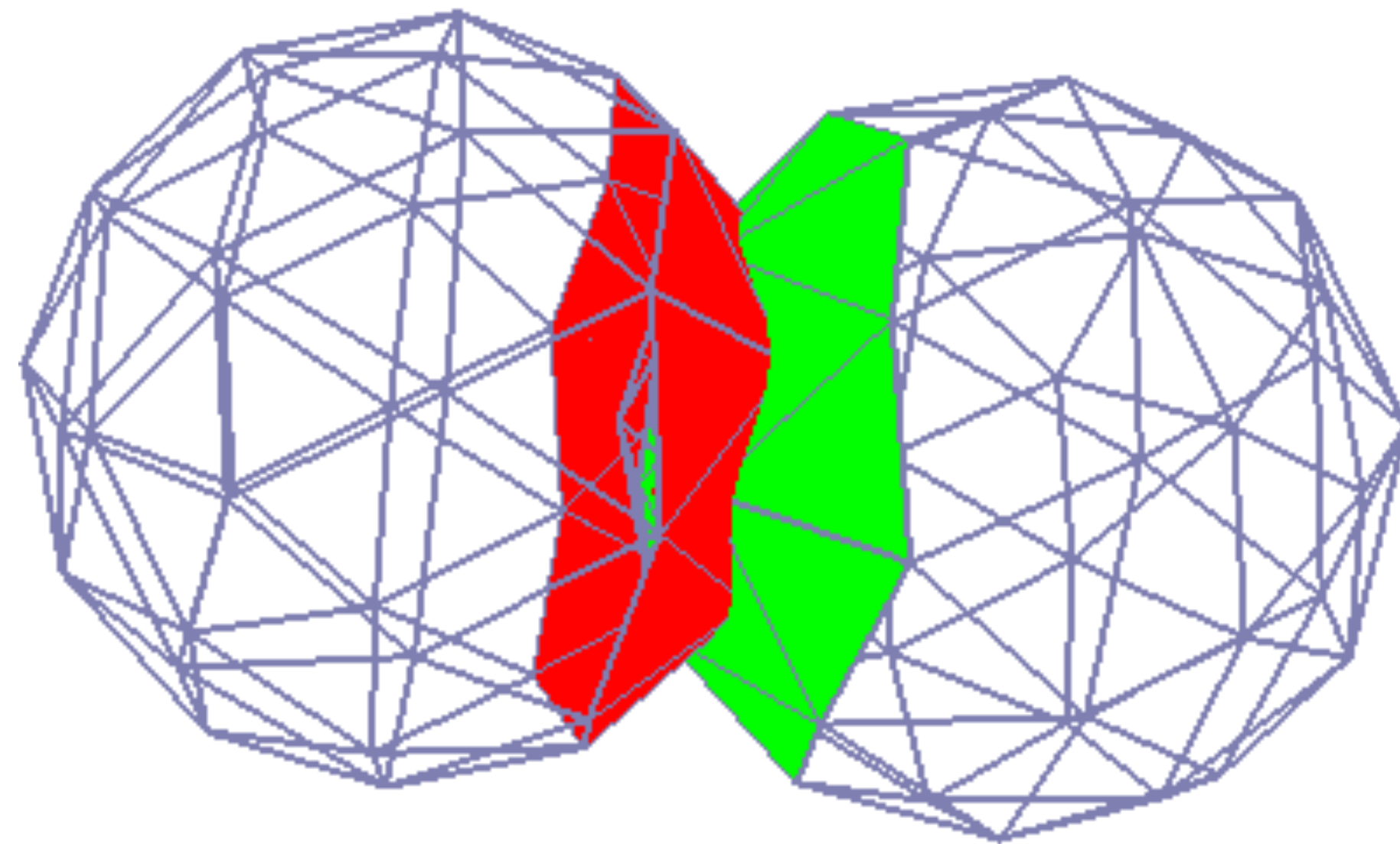
# Semantic Collision Detection & Proximity Query

**Toni Tan**, René Weller, Gabriel Zachmann

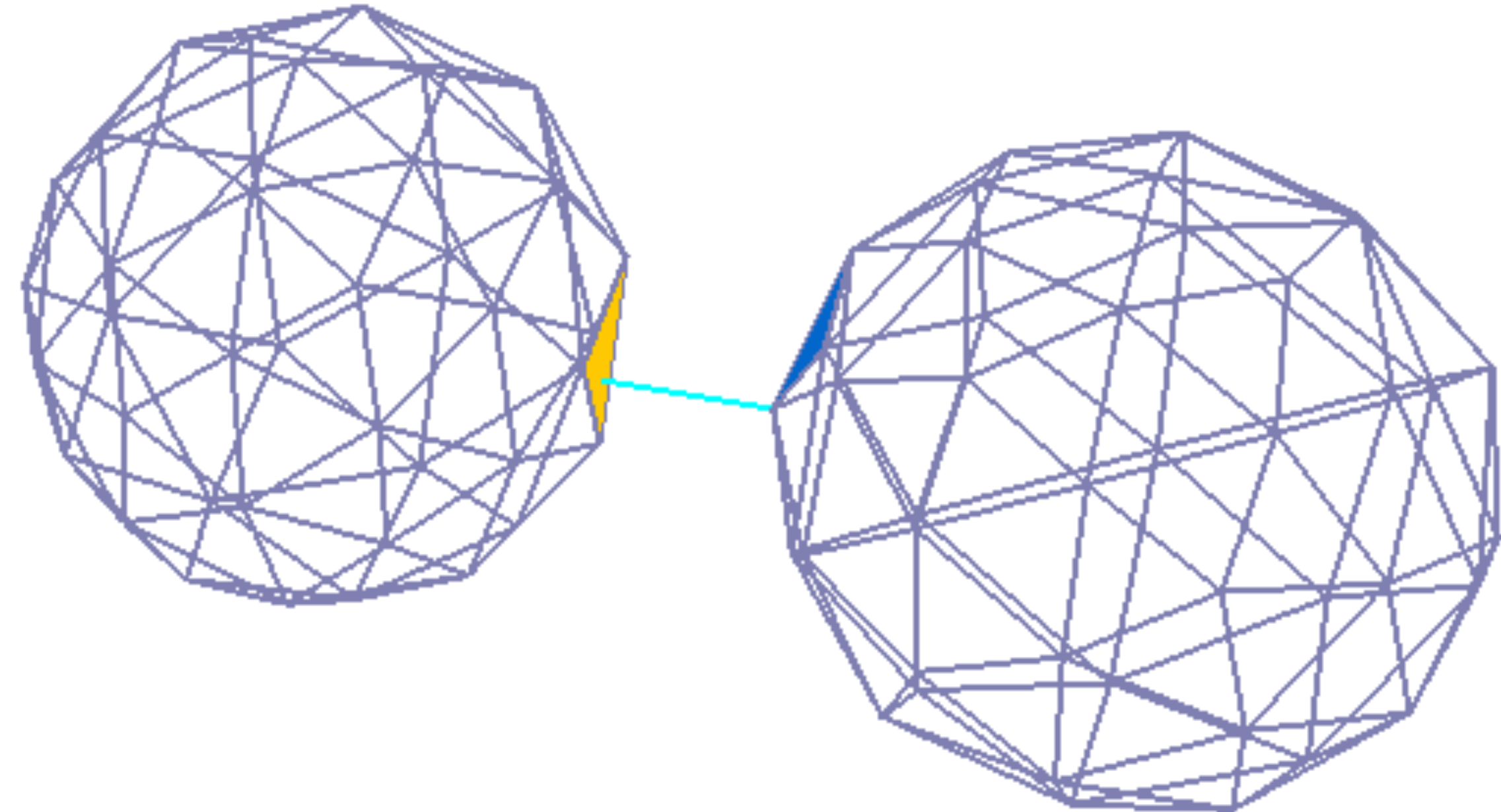
Institute for Computer Graphics and Virtual Reality  
University of Bremen, Germany  
[cgvr.cs.uni-bremen.de](http://cgvr.cs.uni-bremen.de)

September 2020

# Problem Definition



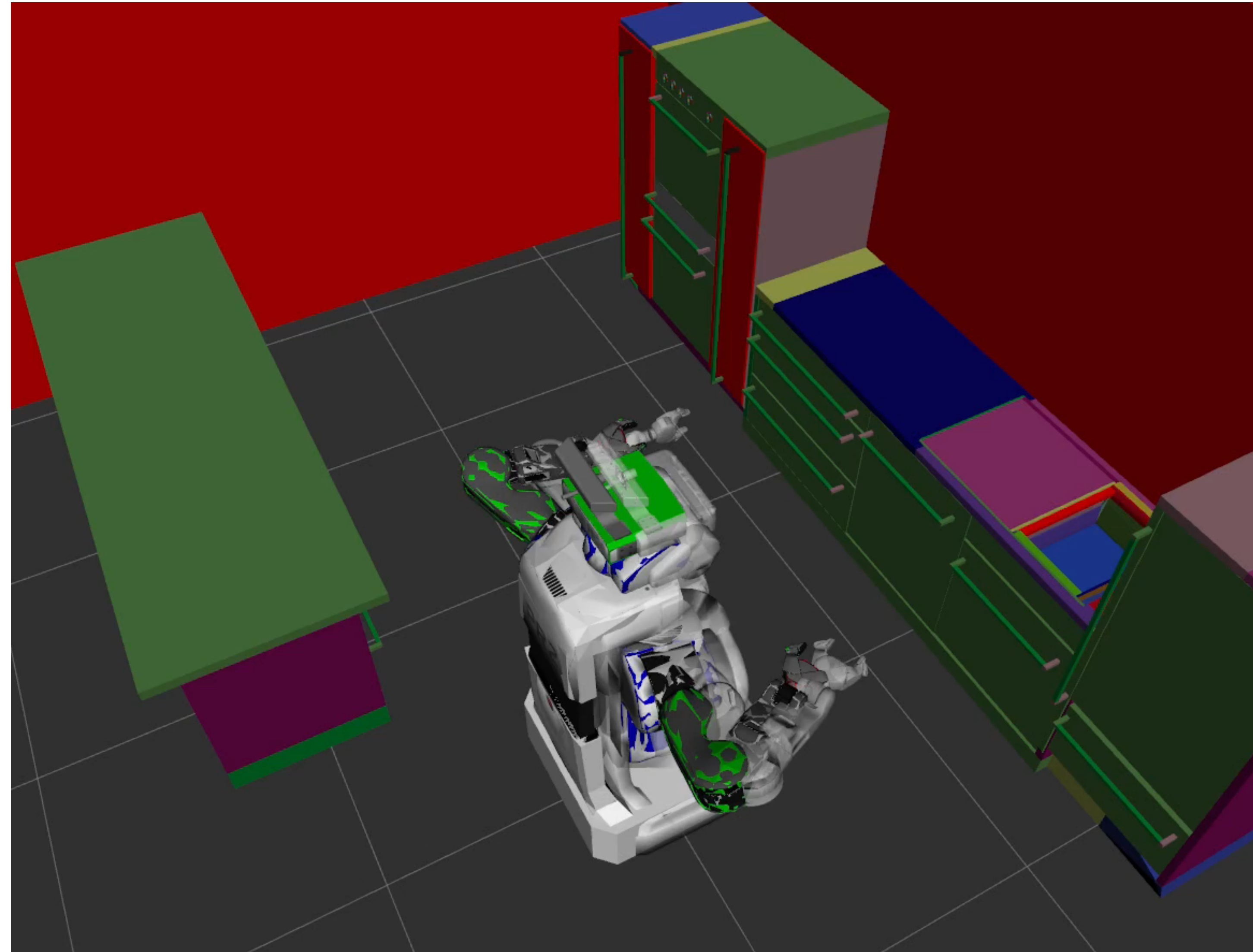
Collision Detection (CD)



Proximity Query (PQ)

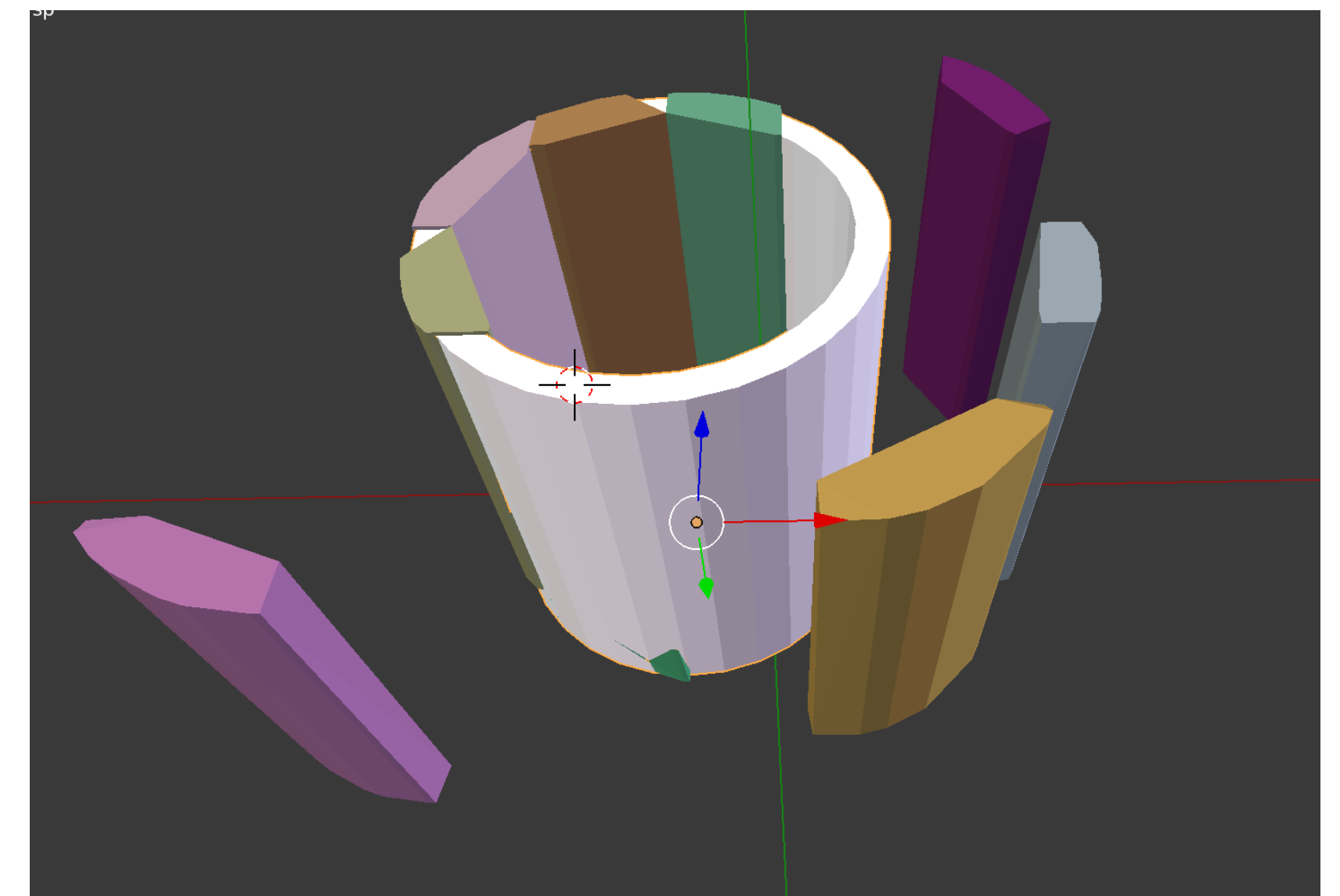
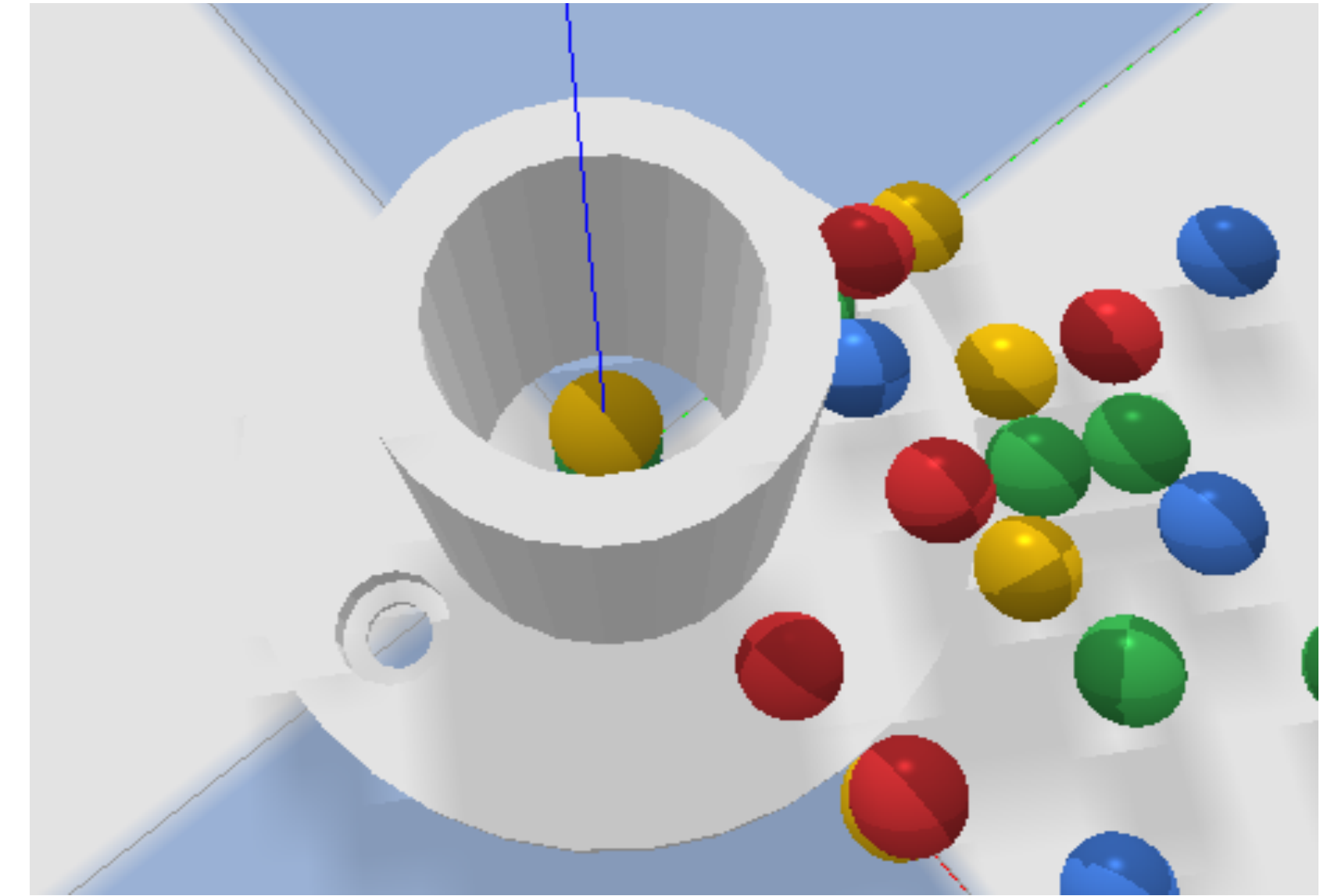


# Giskard – Robot Motion Control

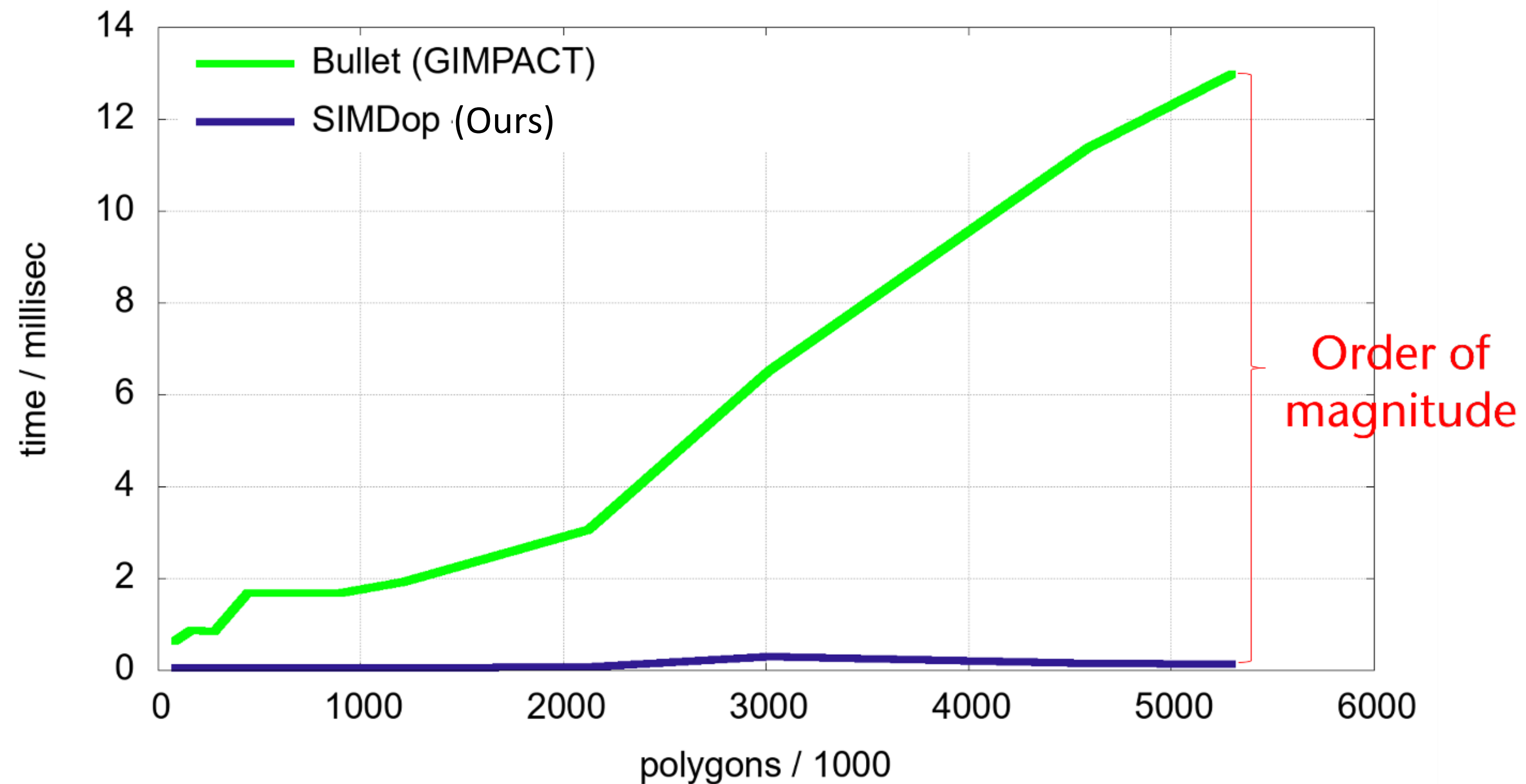


# Giskard - Challenges

- Collision computation (CD) & proximity query (PQ) take large amount of computation time.
  - up to 90% in most sampling-based motion planning
- [Reggiani et al., 2002].
- Bullet does not handle CD & PQ well
  - Approximation based on convex hull
  - For concave object, use convex decomposition



- Exact CD (GIMPACT) possible but slow



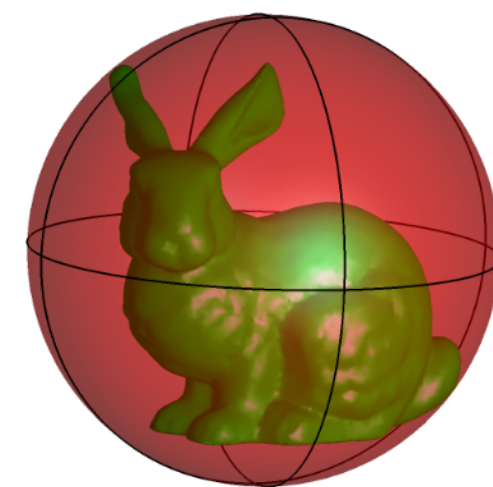
# Giskard - Improvements

- CD (DopTree, BoxTree, SIMDop, V-COLLIDE, PQP) & PQ (SIMDop, PQP)
  - Exact result
  - Works with arbitrary geometry
  - Faster than bullet (GIMPACT) for exact result
- Which CD & PQ algorithm to use?

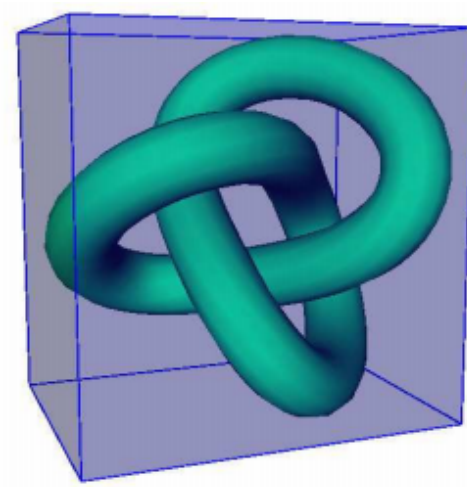


# CD & PQ: Recap

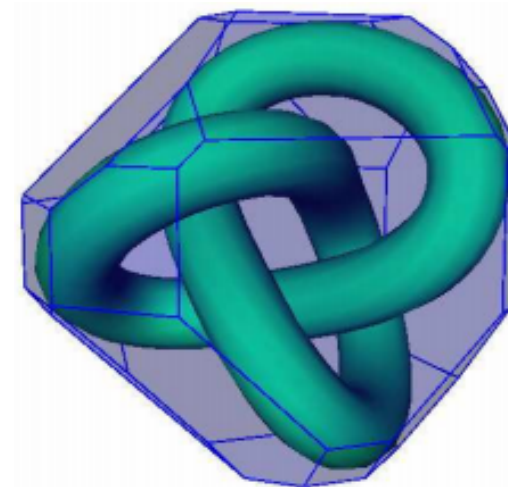
- Approximation
  - Based on convex decomposition
- Exact
  - For rigid bodies, mostly based on BVH



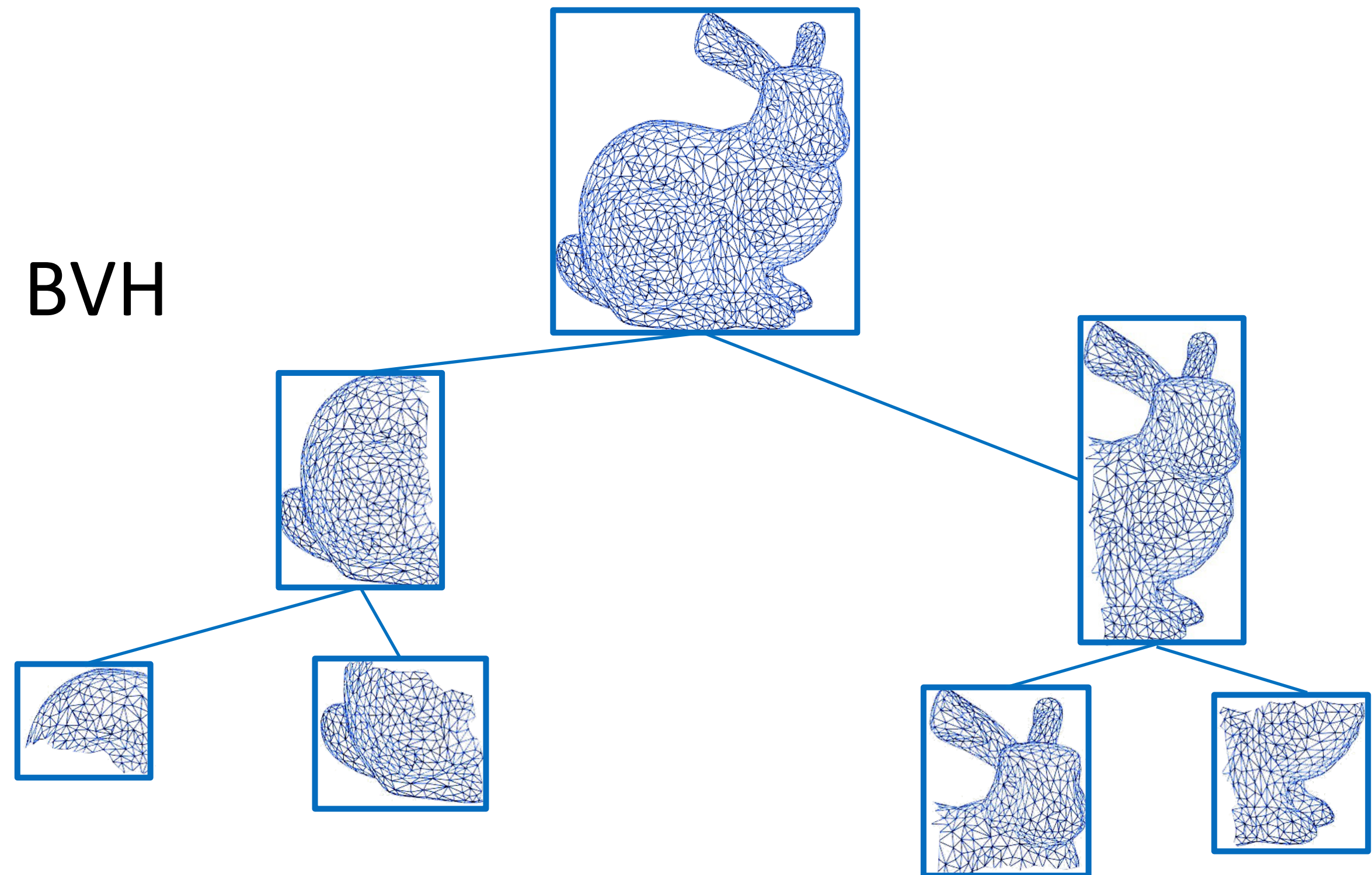
**Sphere**



**AABB**

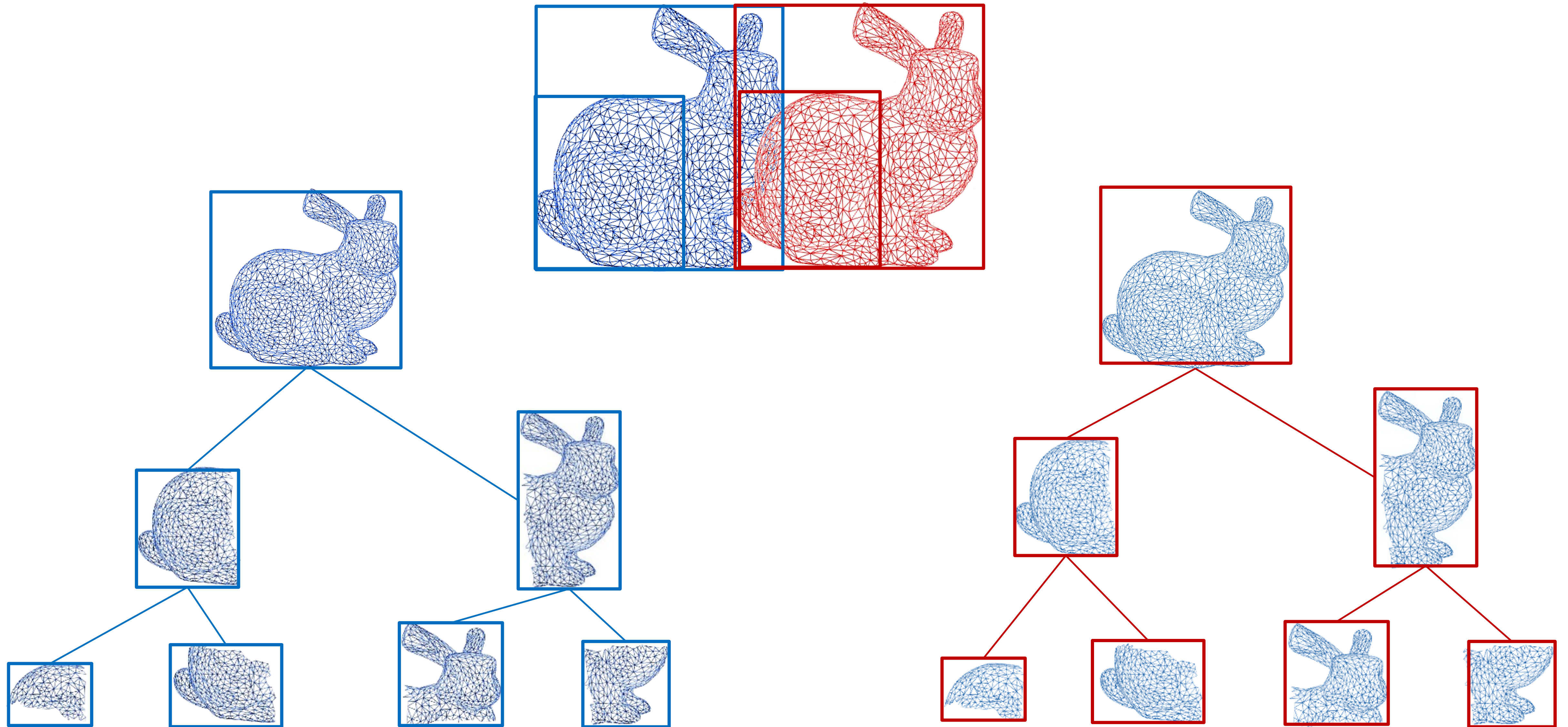


**k-DOP**





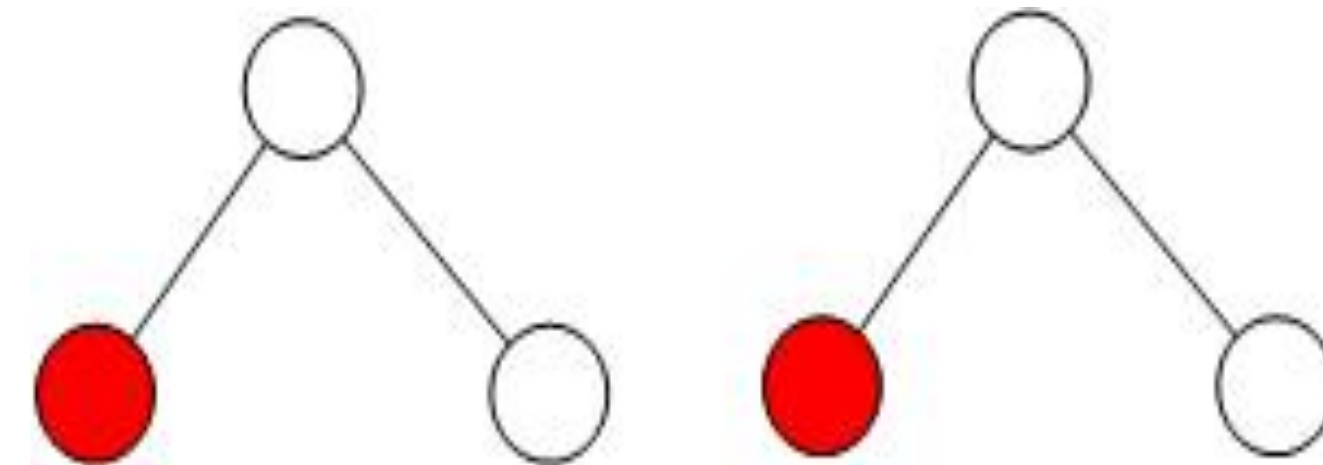
# CD & PQ: Recap





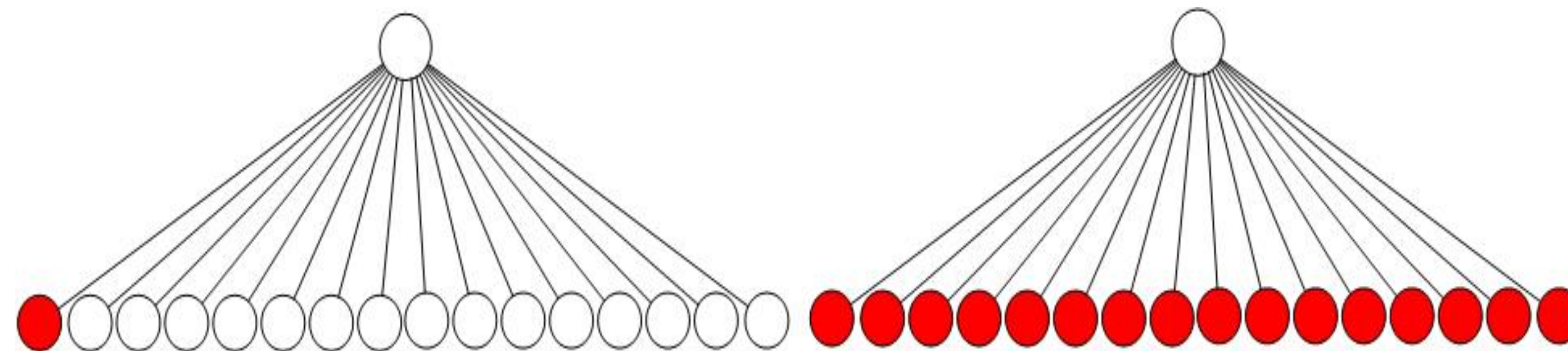
# CD & PQ: Recap

- Simultaneous traversal

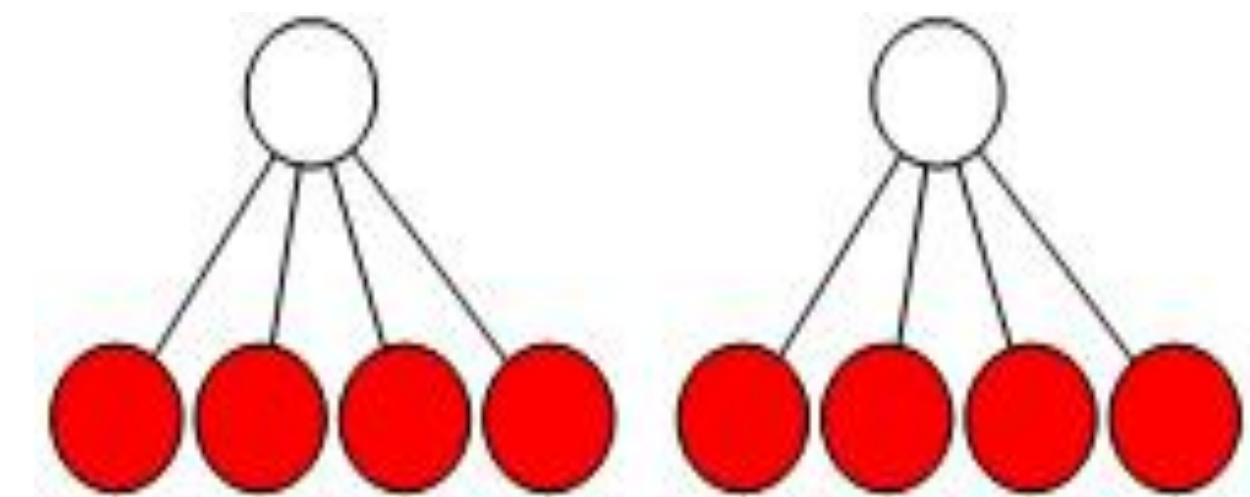


**1 vs 1**

- SIMD optimized simultaneous traversal using AVX512 [Tan et al., 2019]



**1 vs many**



**many vs many**

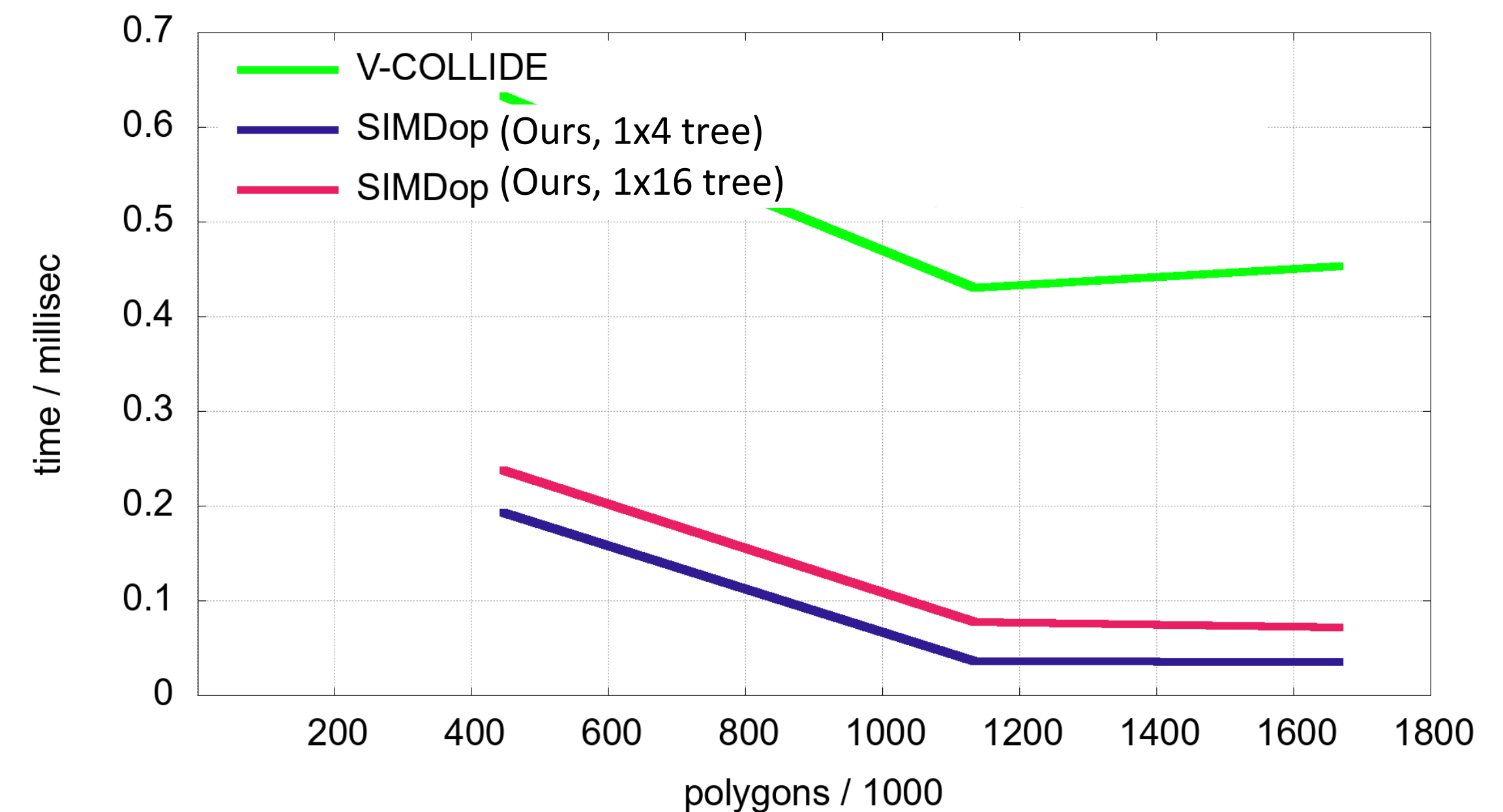
# CD & PQ: Practical Challenges

- CD & PQ algorithm depends on many factors
  - Object's polygon
  - Object's shape and used BV
    - Obviously, sphere BV will fit better for ball object compared with AABB
  - Object's configuration
    - Slightly change can results in completely different timings



# CD & PQ: Practical Challenges

- Benchmarking process is often difficult and time-consuming
  - Require prior knowledge about algorithms and benchmarking tools
  - Hardware availability
  - Results are not meaningful enough
    - Usually represented using chart or histogram

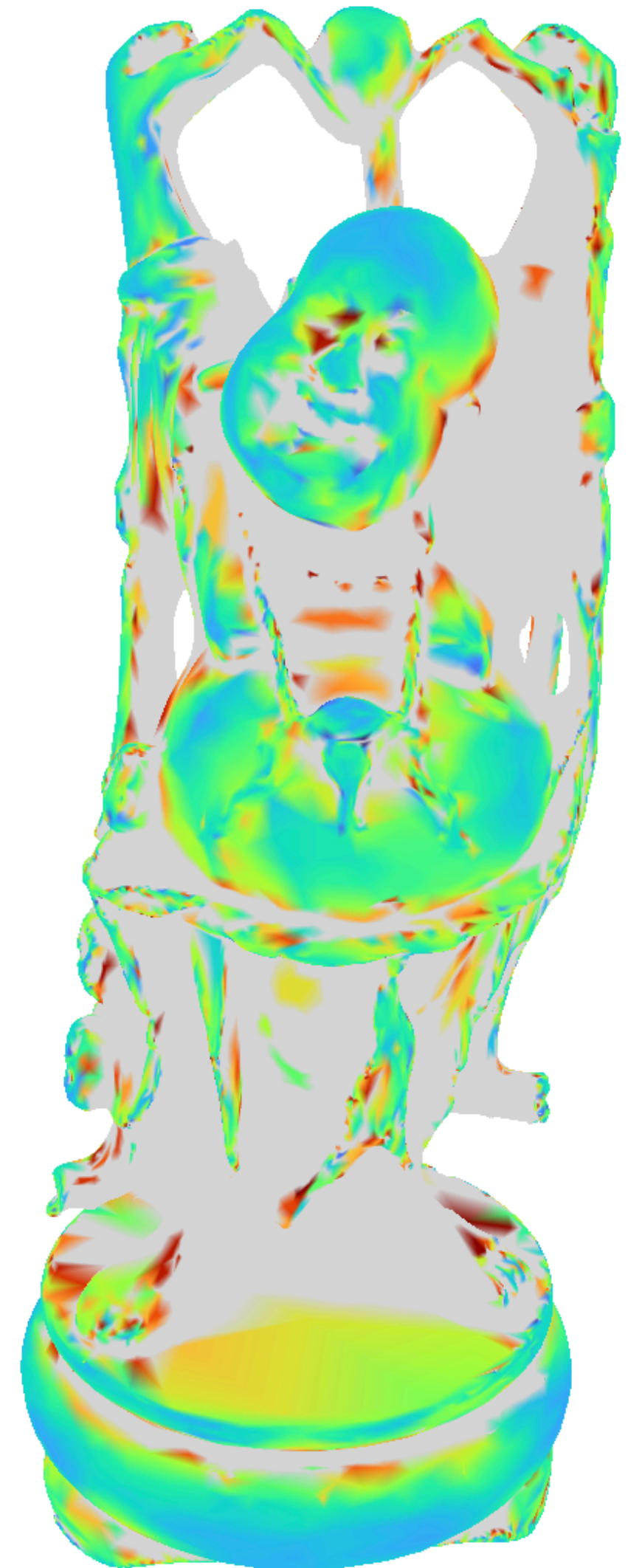


# Our Contribution: Open Benchmark for CD & PQ

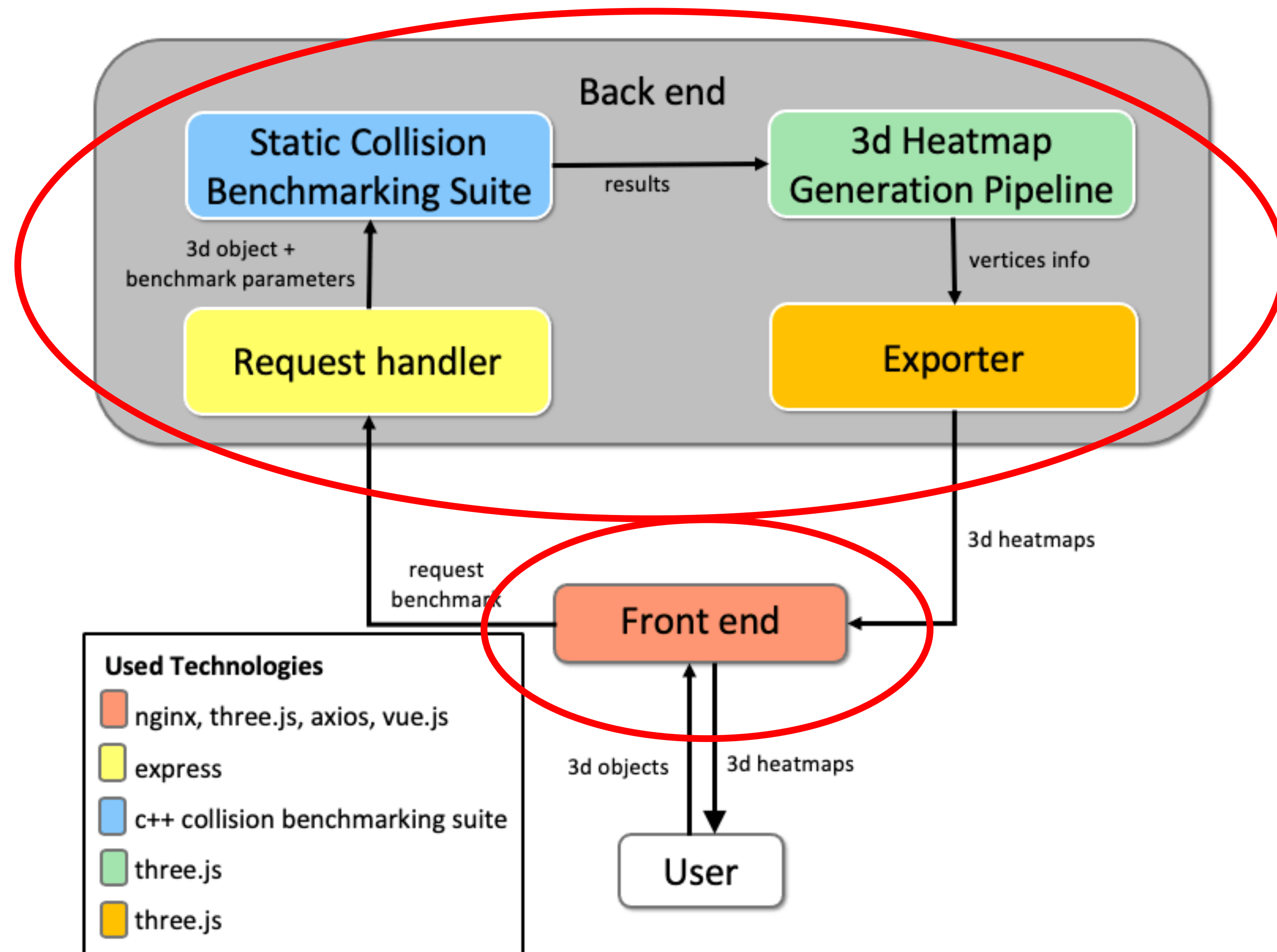
- OpenCollBench: Benchmarking CD & PQ as a web-service

[Tan et al., 2020], accessible at [opencollbench.com](https://opencollbench.com)

- Intuitive & accessible for both expert & non-expert user
- Unified & dedicated hardware
  - Results reproducible
- Semantic information
  - Better understanding of benchmarking results on a sub-object level, e.g.,
    - Identify critical or outlier regions
    - Identify heavily tested configurations
- Open data



# OpenCollBench – System Overview



# OpenCollBench – Web Interface



<b>Object File</b> <input type="button" value="Choose a file"/> <span>bunny.obj...</span>	<b>Benchmark Mode</b> Collision	<b>Algo</b> SIMDop	<b>First / All Collision ?</b> All
<b>Benchmark Configurations:</b> Use Saved Positions	<b>Position Finding Method :</b> Sphere	<b>Rotate Object By Degree</b> 60	<b>Move Object By Degree</b> 30
<b>Relative Distance : 0</b> 0			
<input type="checkbox"/> Remove object after benchmark			
Start			

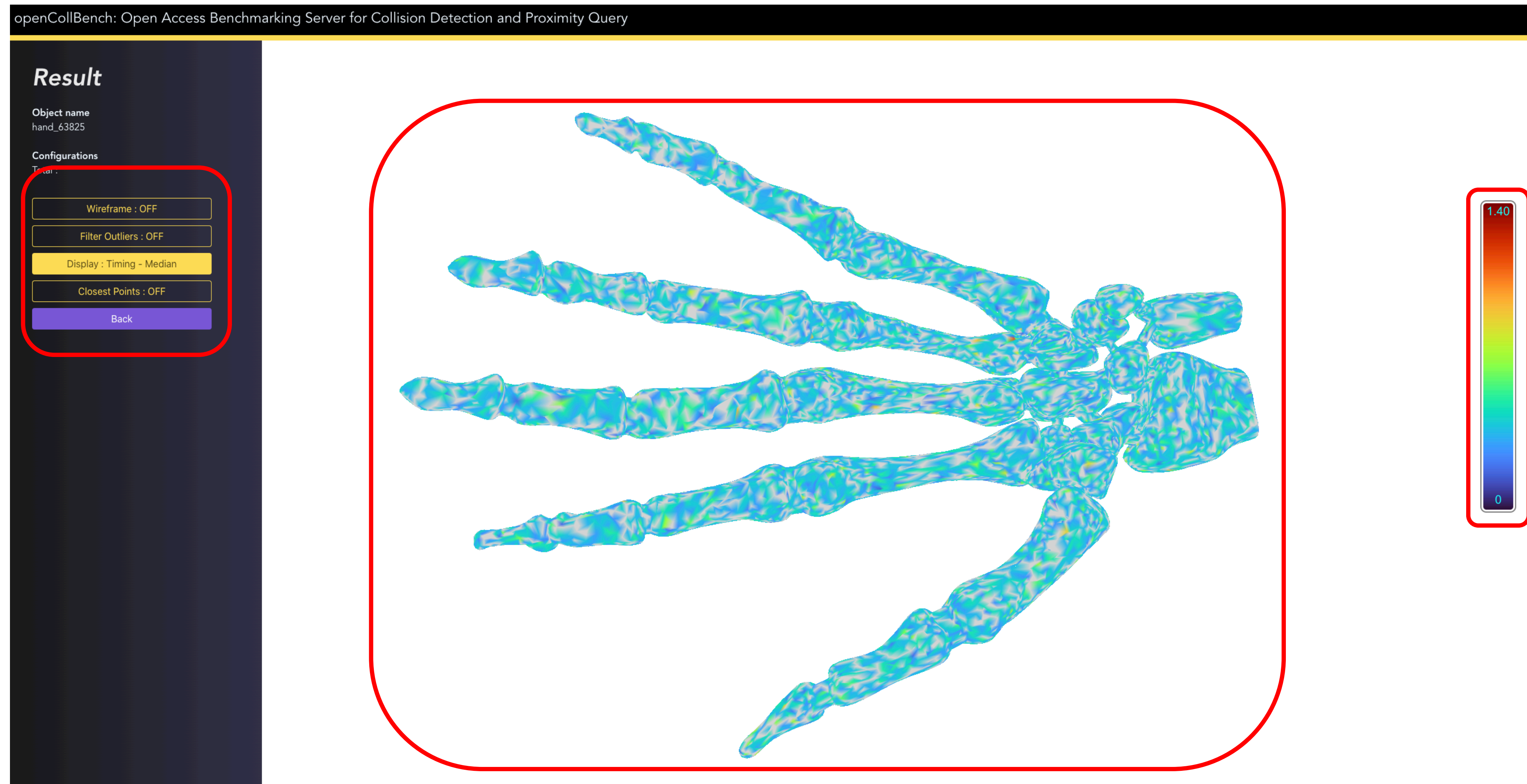


OpenCollBench: Benchmarking of Collision Detection & Proximity Queries as a Web-Service



Benchmark is running.  
You can safely close your browser and come back later to check result.

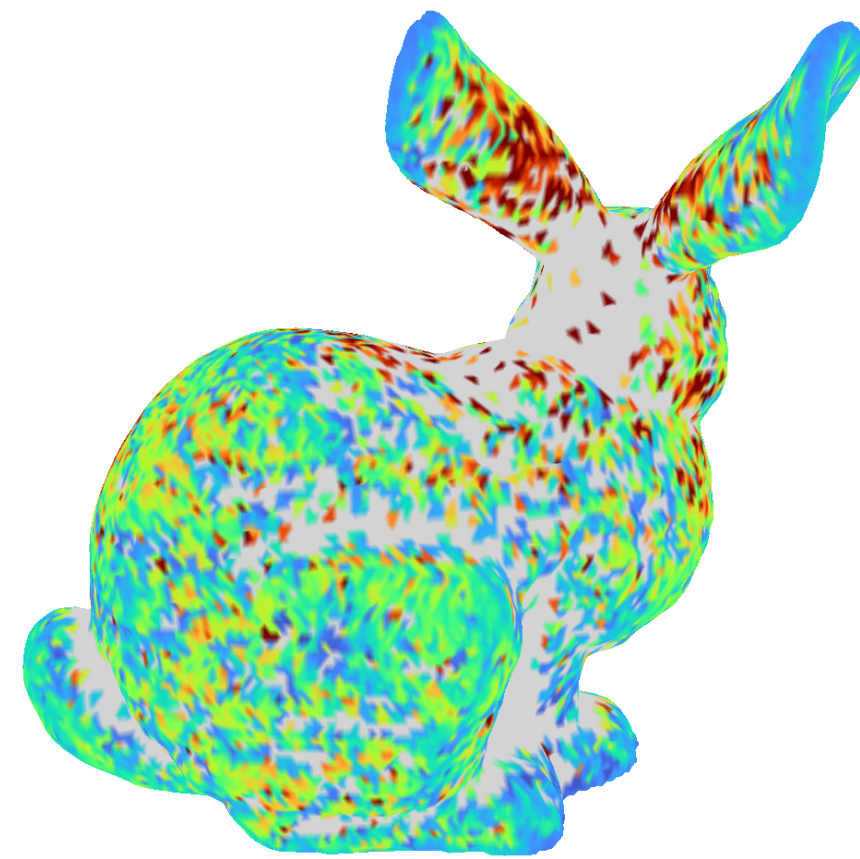
# OpenCollBench – Result Page



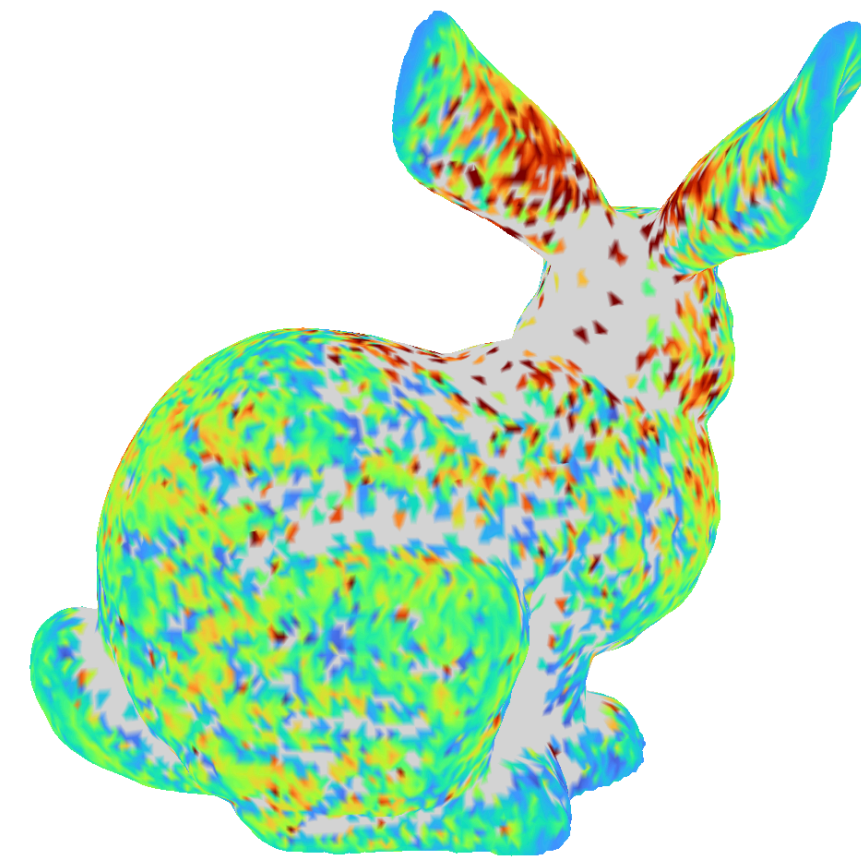
## Short Video – OpenCollBench Demo



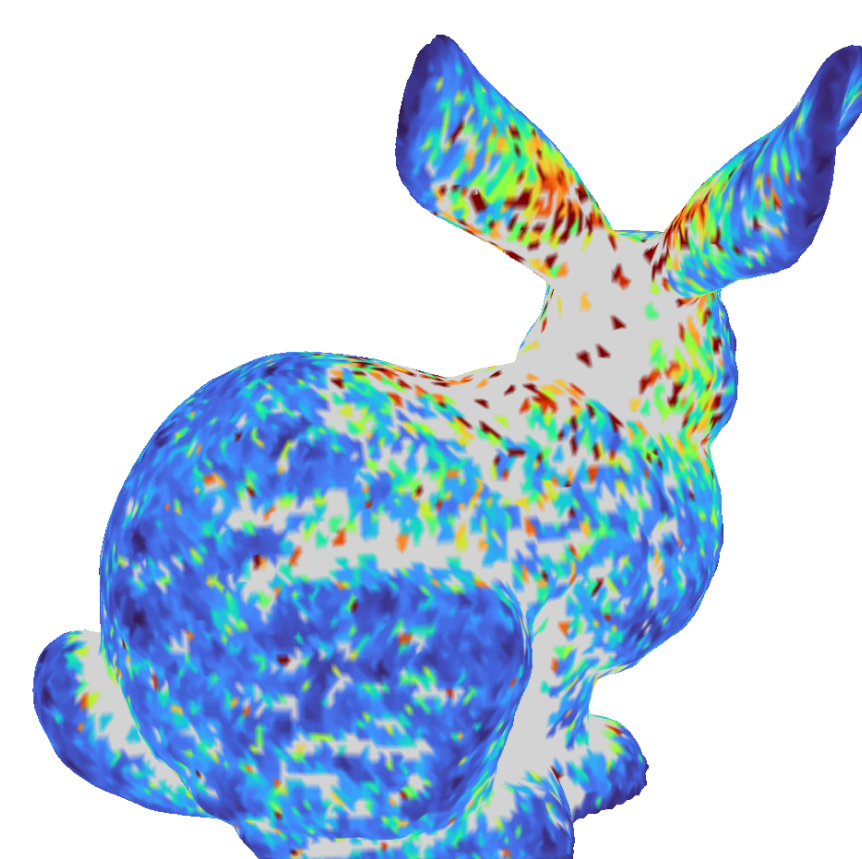
# Semantic CD & PQ



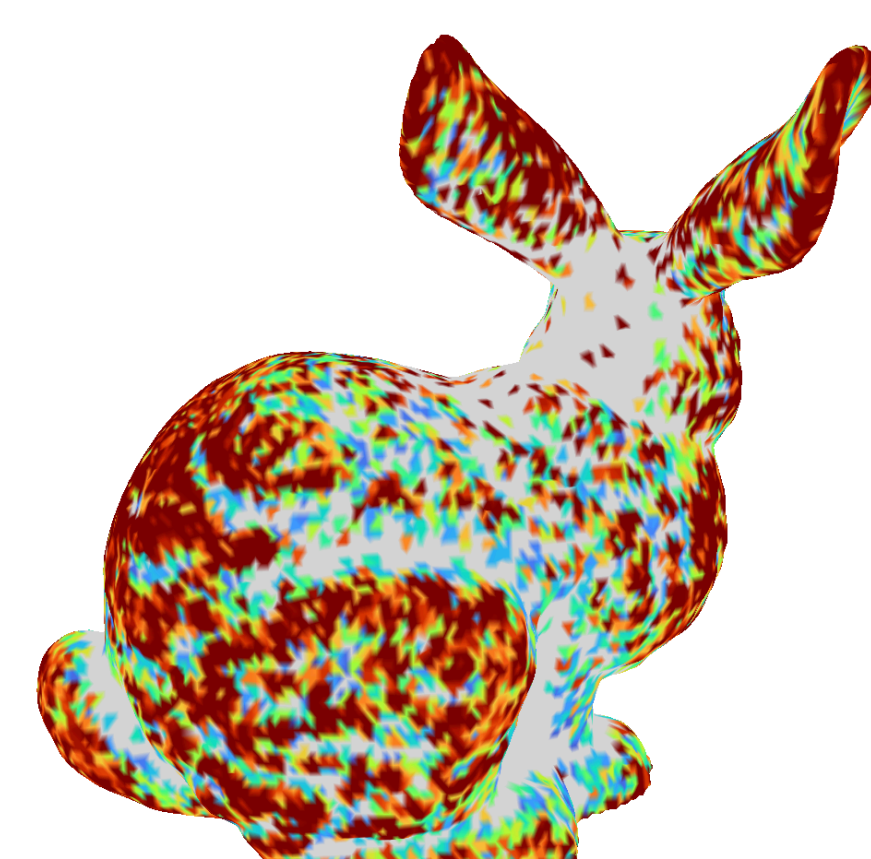
Median timings



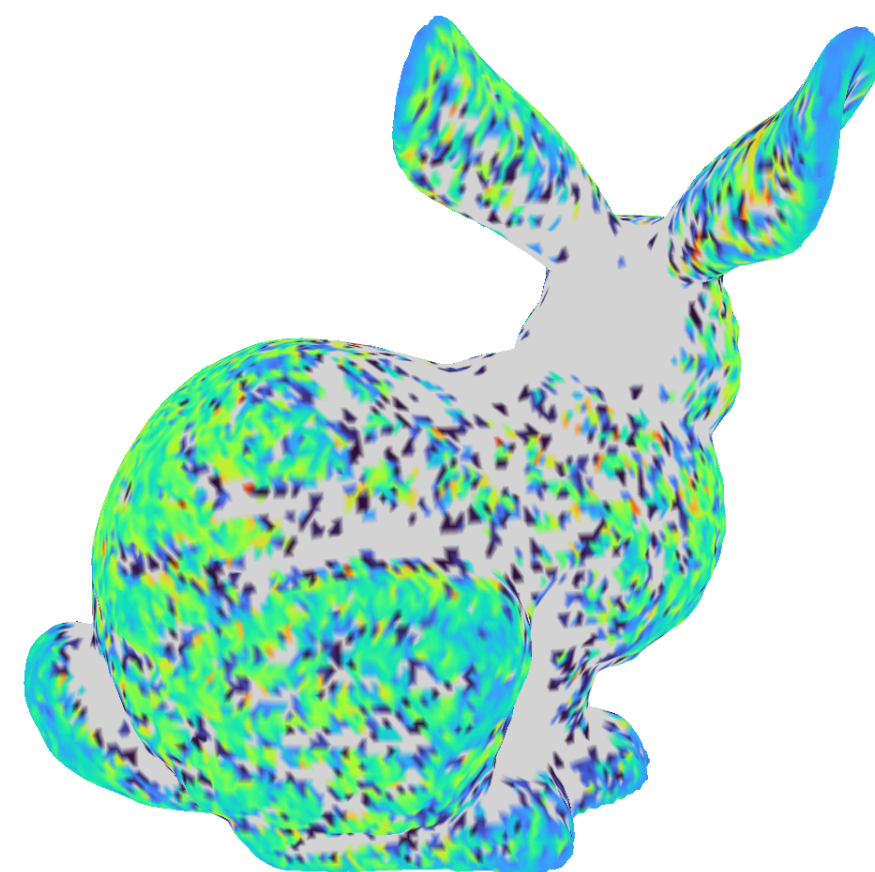
Average timings



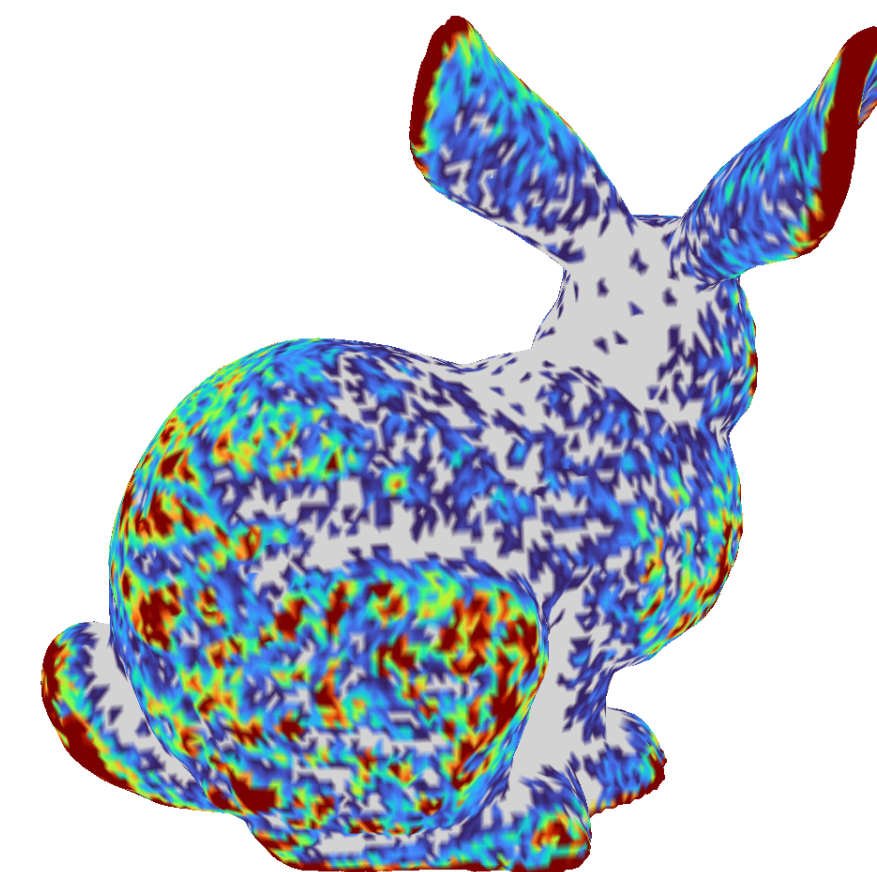
Min timings



Max timings



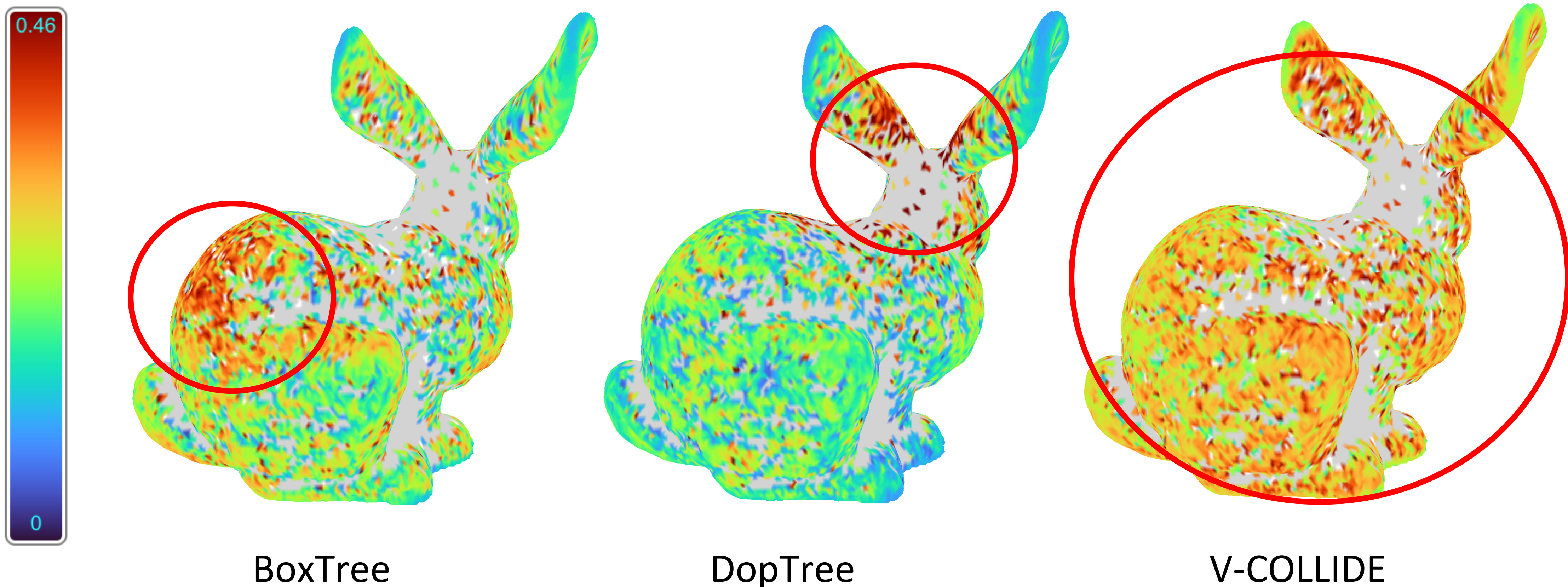
Standard deviation



Configurations density

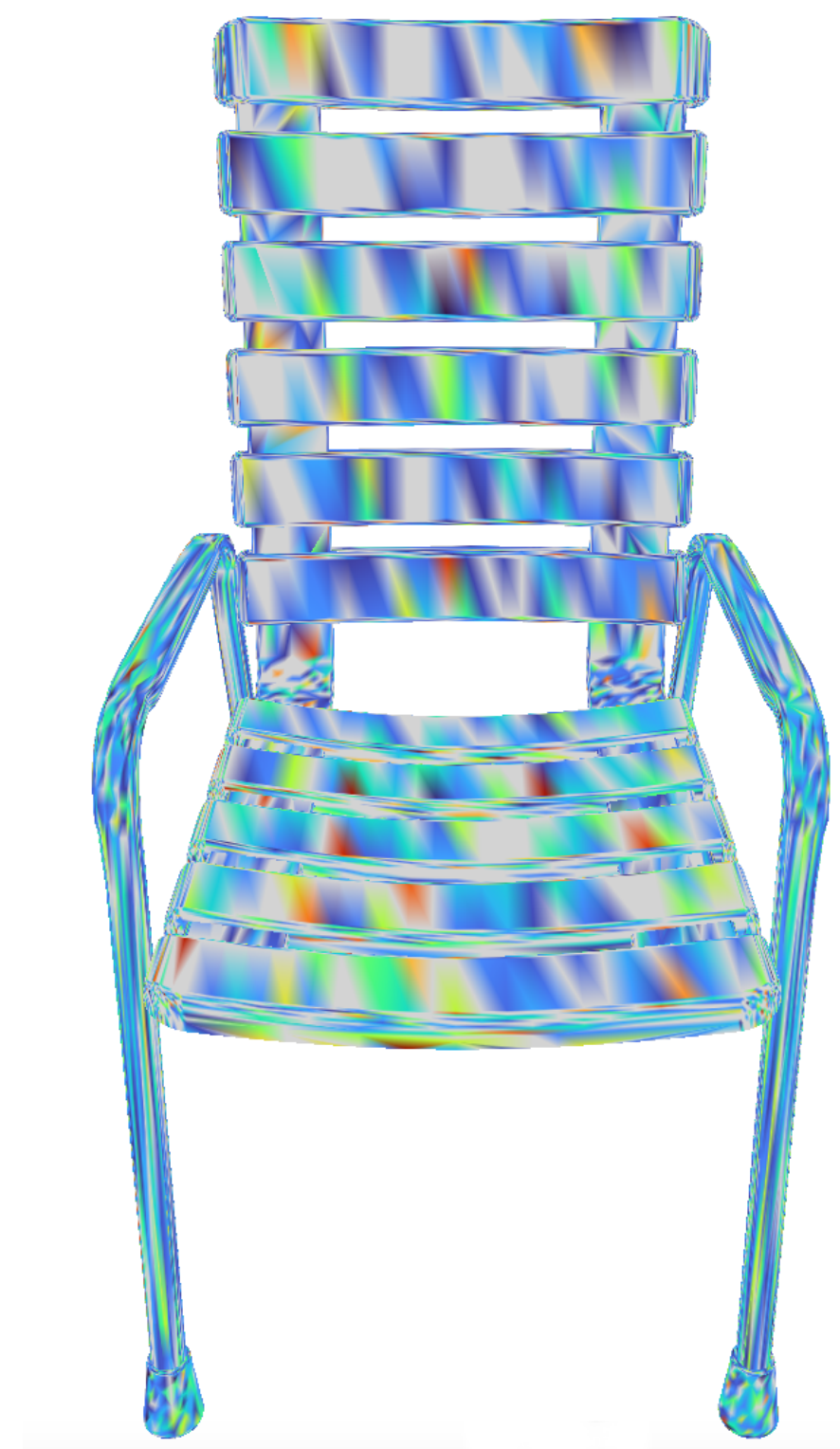


# Semantic CD & PQ: Critical or Outlier Regions





# Semantic CD & PQ: Heavily Tested Regions



distance of 0.0



distance of 0.2



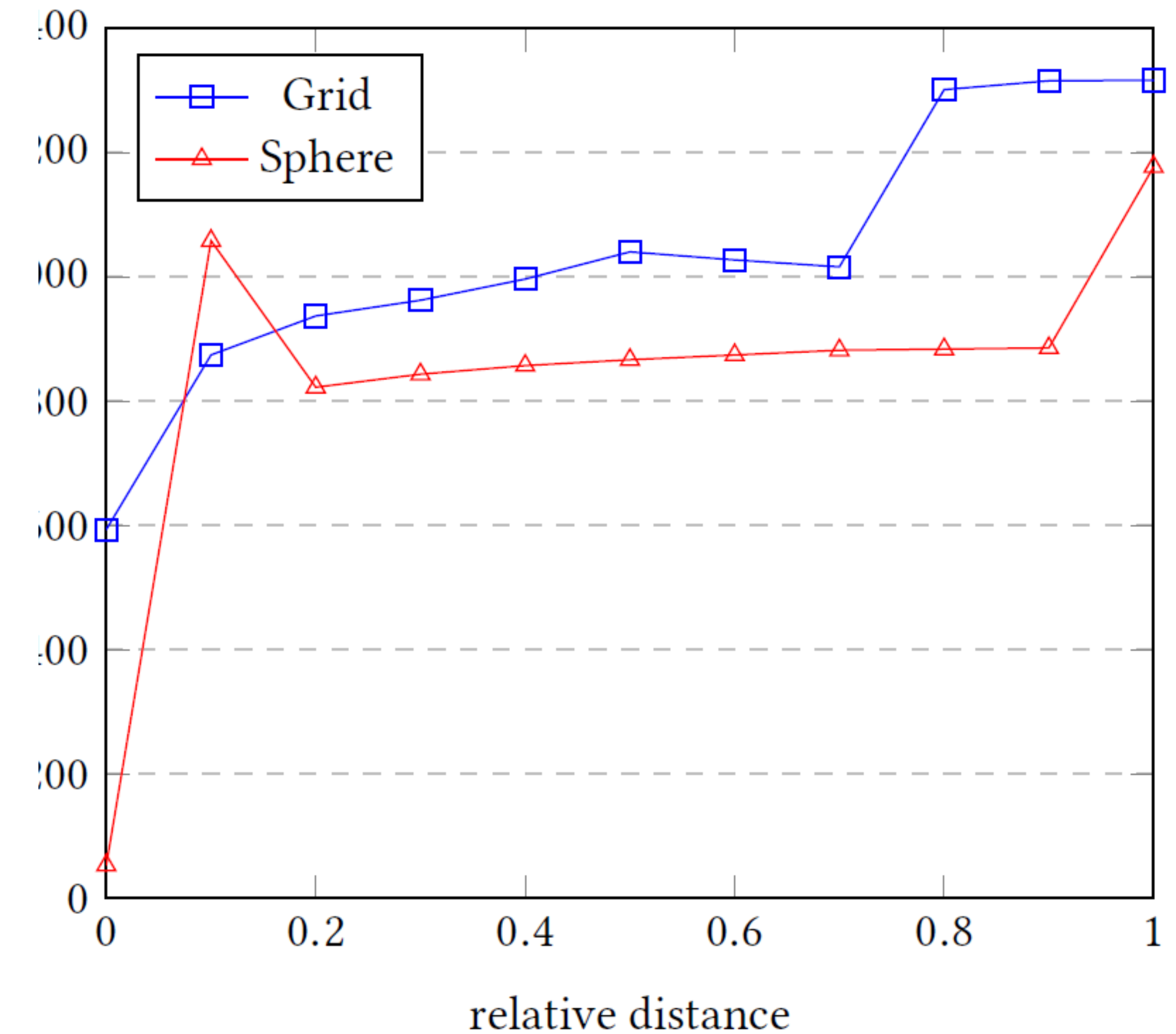
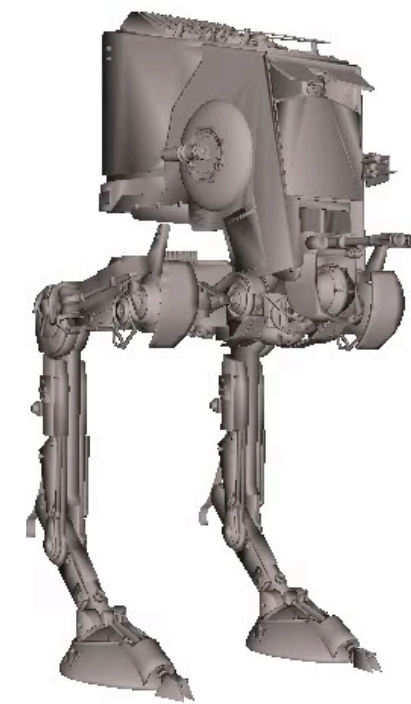
distance of 0.4



distance of 0.6

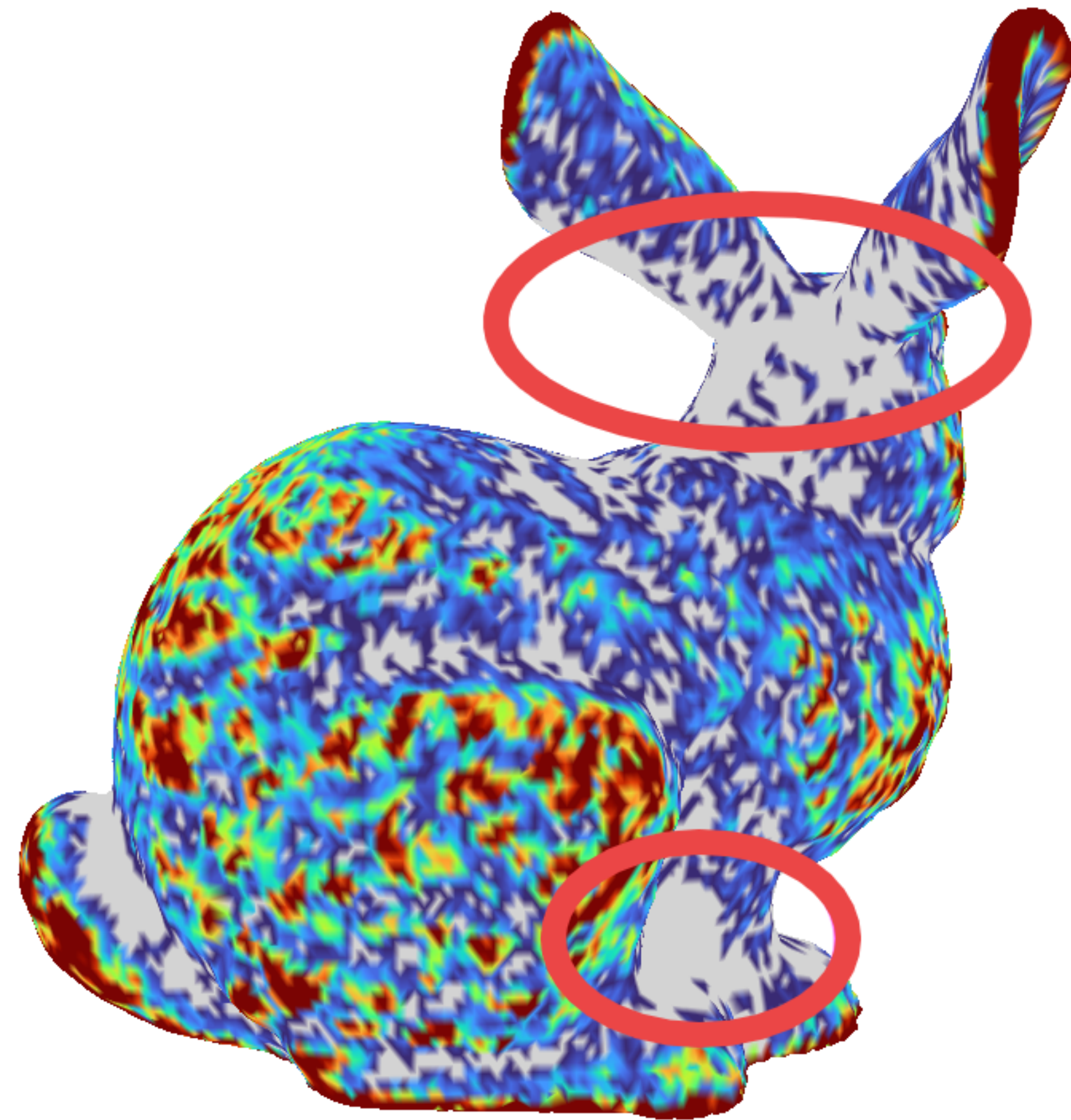
# Semantic CD & PQ: Configuration Generations

- Position finding based on Sphere & Grid method.

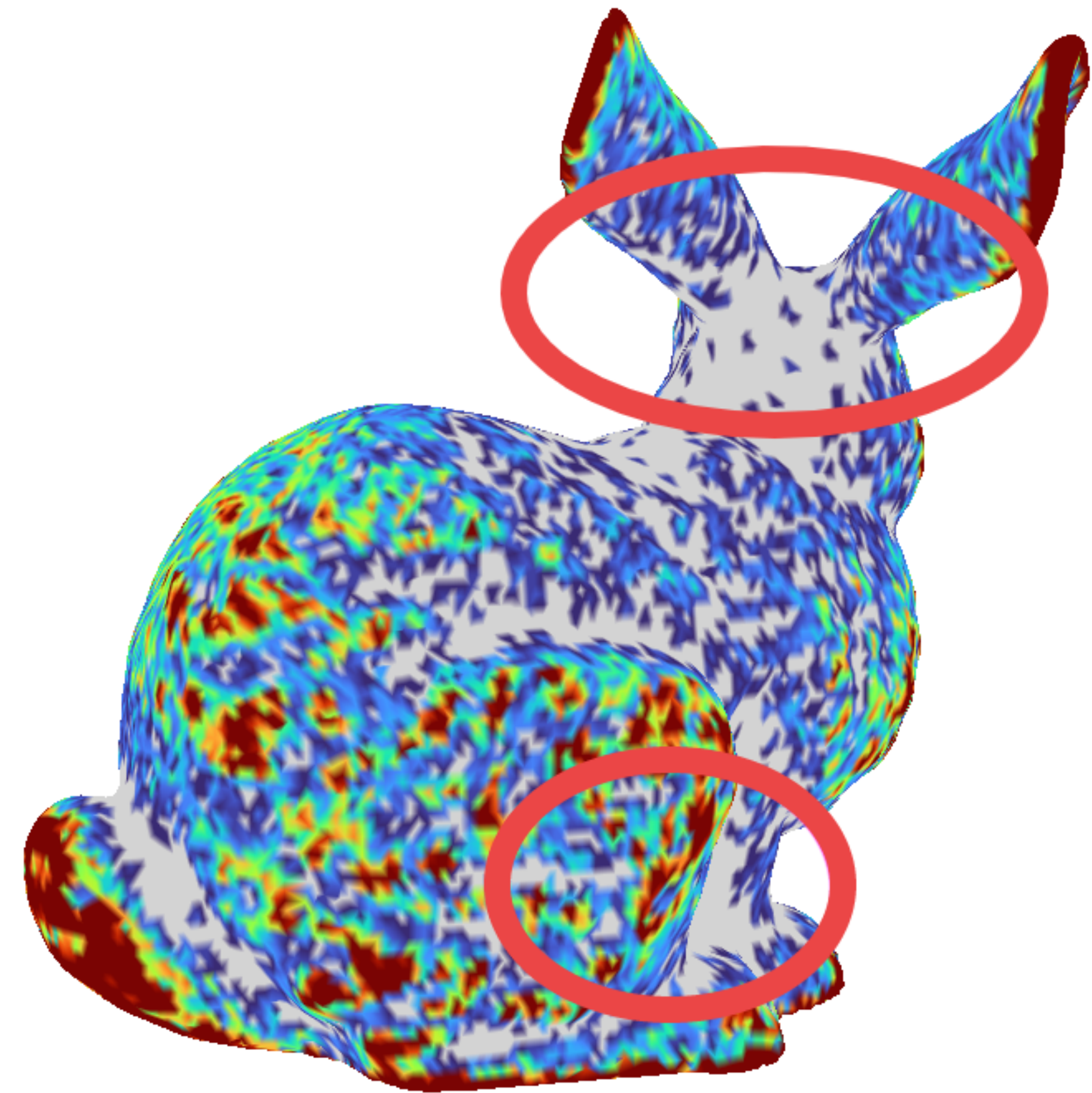




# Semantic CD & PQ: Heavily Tested Regions



Sphere method



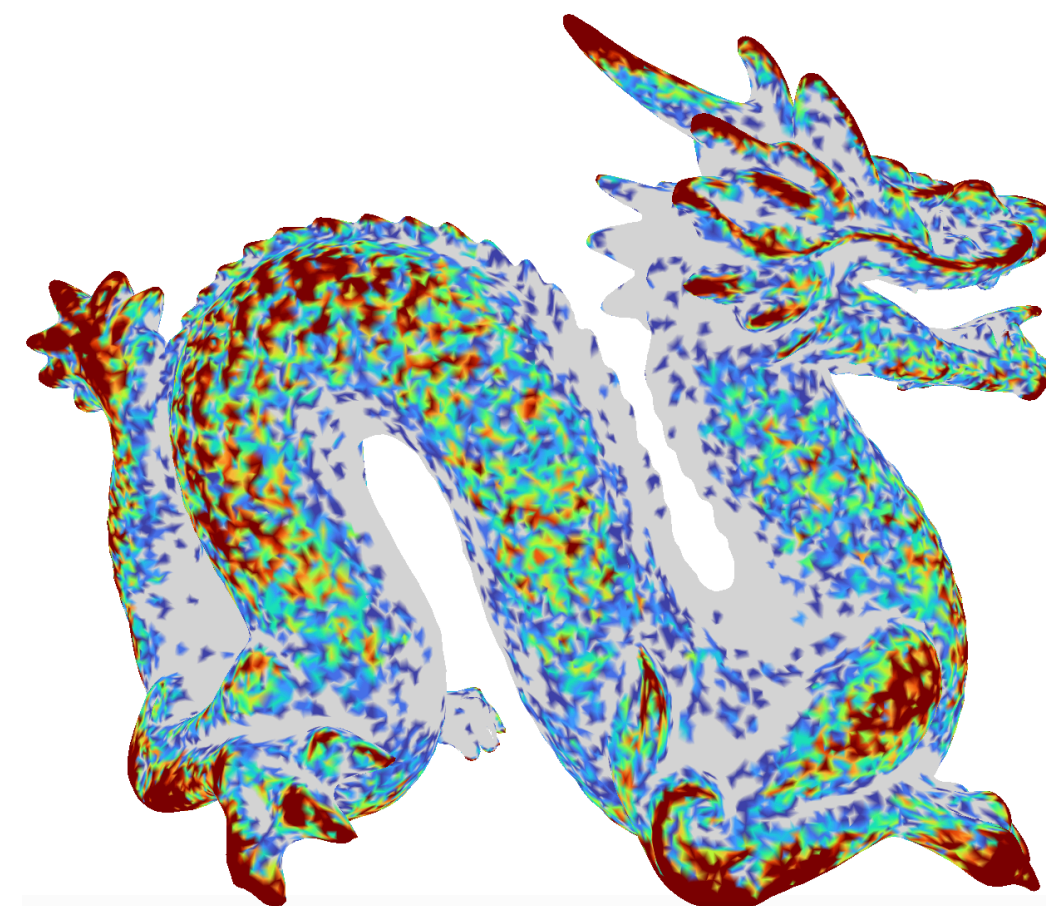
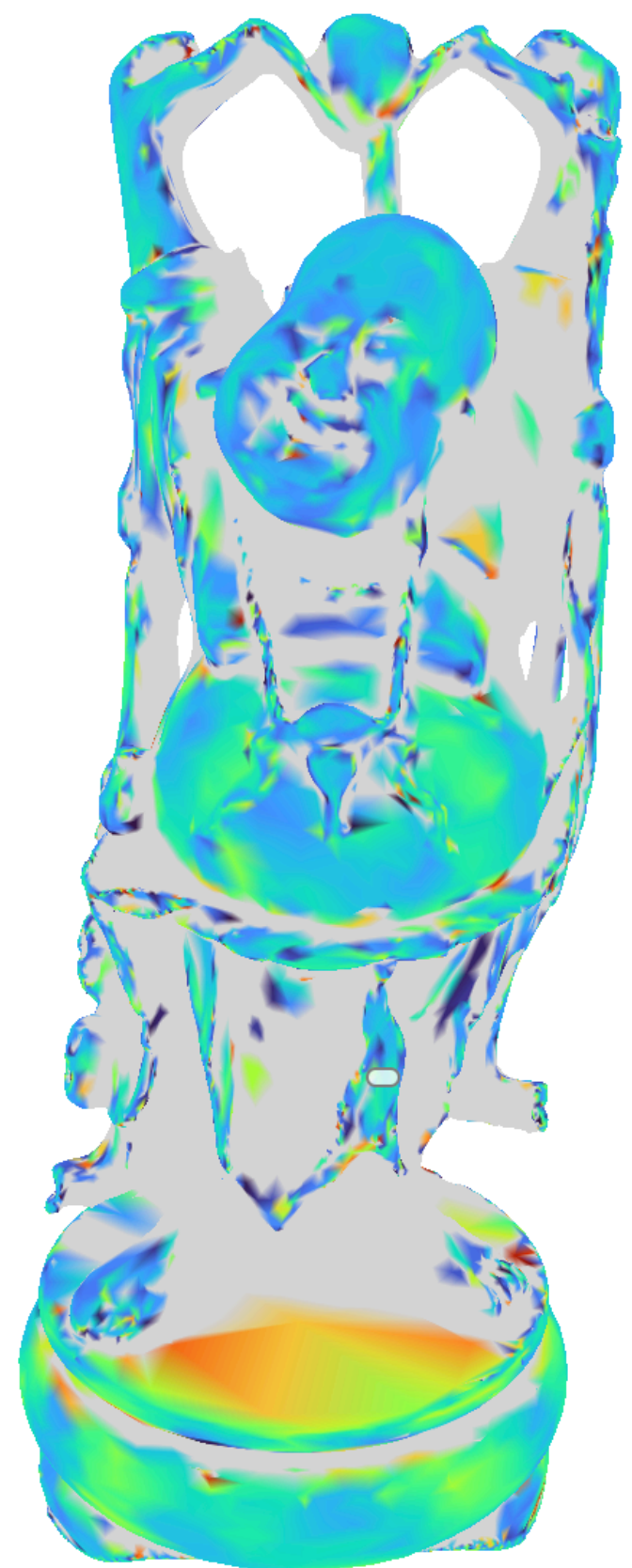
Grid method



# Conclusions

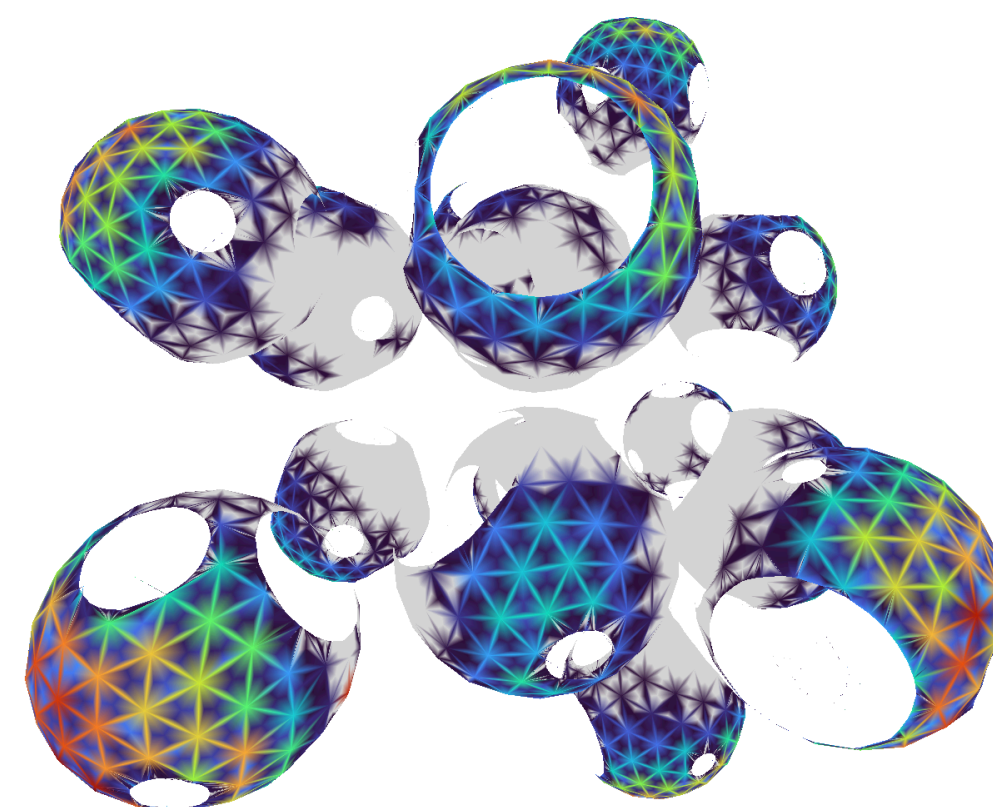
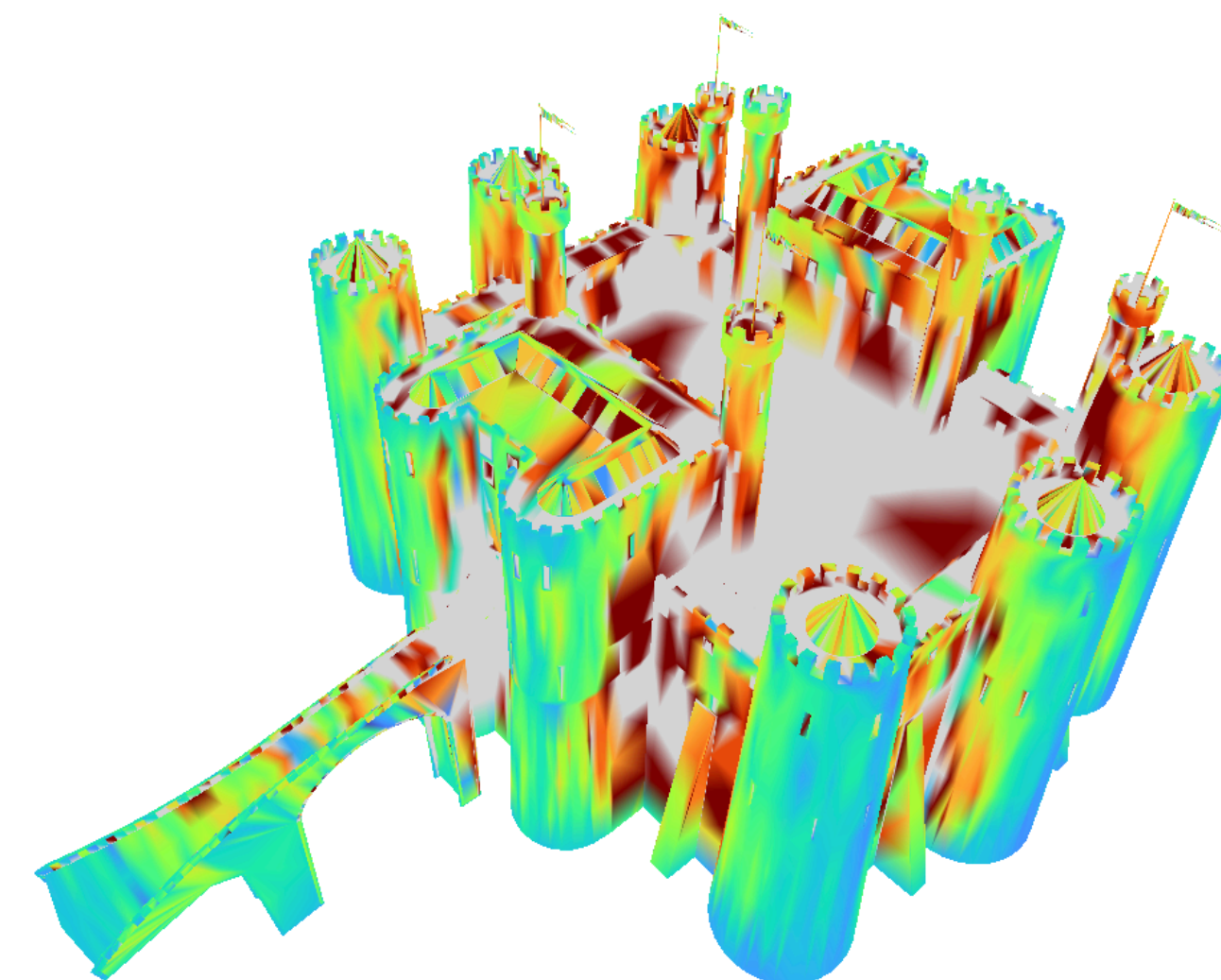
- Novel, semantic information based on benchmarking results
- Sub-object level accuracy for analysis of benchmarking results
- New proposal: open Benchmarking of CD & PQ as a web service
- Future work:
  - Extend to cover more cases related to CD & PQ, .e.g., deformable objects, GPU-based algorithms, etc
  - Allow user to upload their own CD & PQ algorithms and compare with existing one.

# Thank You!



Toni Tan, René Weller, Gabriel Zachmann

{**toni**, weller, zach}@cs.uni-bremen.de





# Source of images

- Convex decomposition
  - <https://github.com/bulletphysics/bullet3/issues/1507>
- Concave problem
  - <https://github.com/bulletphysics/bullet3/issues/2531>
- 26-DOP & AABB
  - [http://www-ljk.imag.fr/Publications/Basilic/com.Imc.publi.PUBLI\\_Inproceedings@117681e94b6\\_1860ffd/bounding\\_volume\\_hierarchies.pdf](http://www-ljk.imag.fr/Publications/Basilic/com.Imc.publi.PUBLI_Inproceedings@117681e94b6_1860ffd/bounding_volume_hierarchies.pdf)

All website: last visited at 17.09.2020