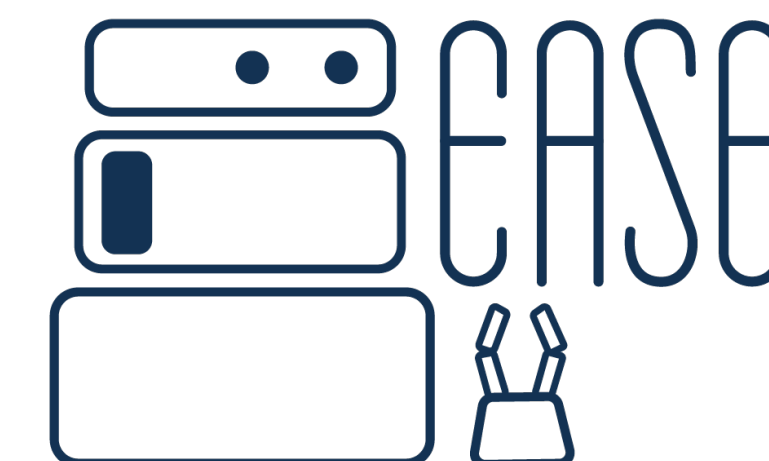


A Framework for Safe Execution of User-Uploaded Algorithms Benchmark as an Online Service (BOS)

Toni Tan, René Weller, Gabriel Zachmann
Computer Graphics and Virtual Reality Research Lab
University of Bremen, Germany

Web3D, 2-4 November 2022



Benchmarks are Important for Scientific Progress

- Replication Crisis
 - Lack of instructions, missing data/codes, incompatible hardware/software, etc
 - In computer graphics [Bonneel et al, 2020] :
 - 374 papers from SIGGRAPH 2014, 2016, and 2018
 - 151 software packages available (133 source codes, 18 pre-compiled softwares),
 - 68 source codes need modification to work, 19 technical issues, and 5 hardware issues
- Open Benchmark for reproducible and comparable results

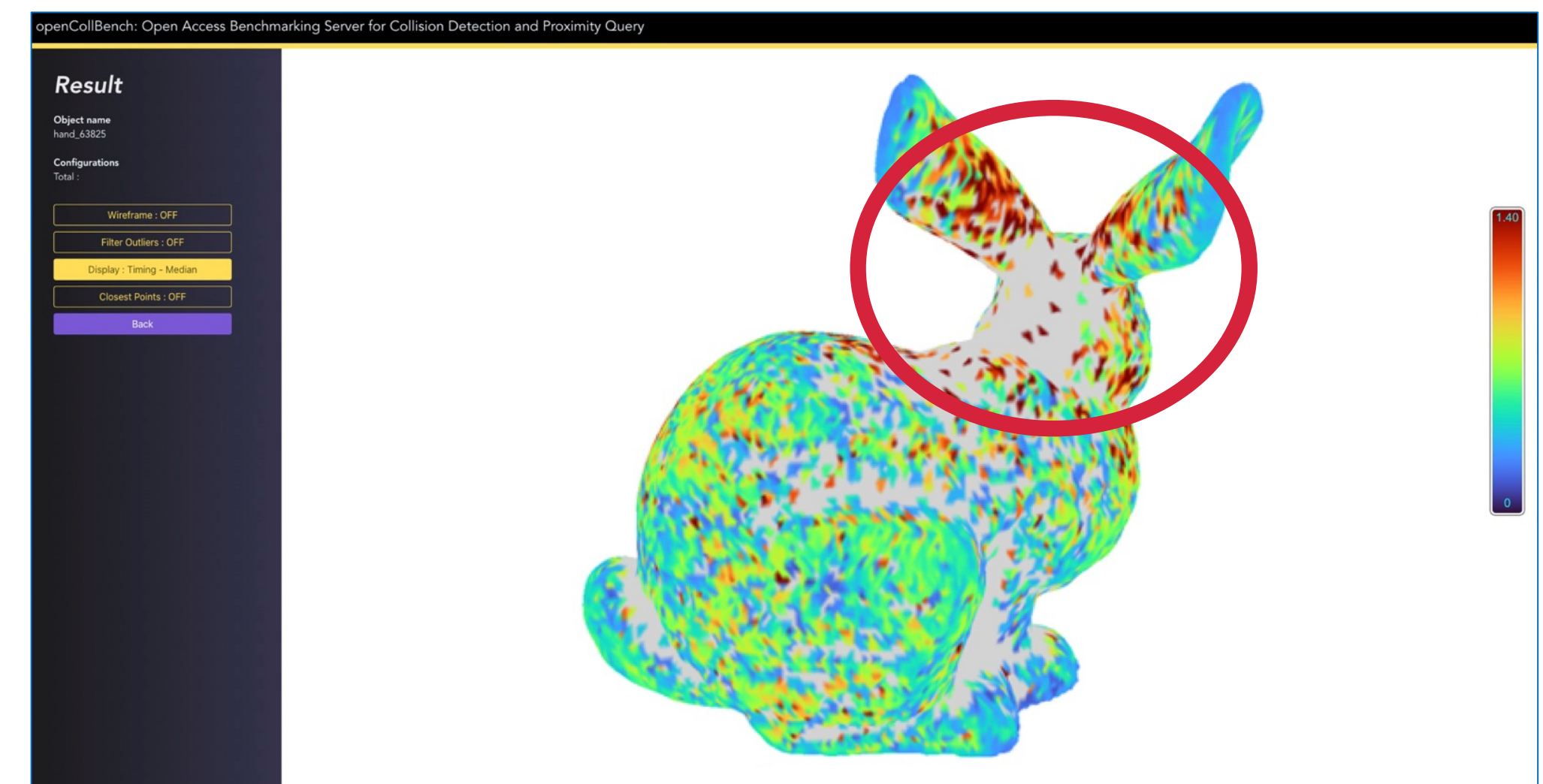
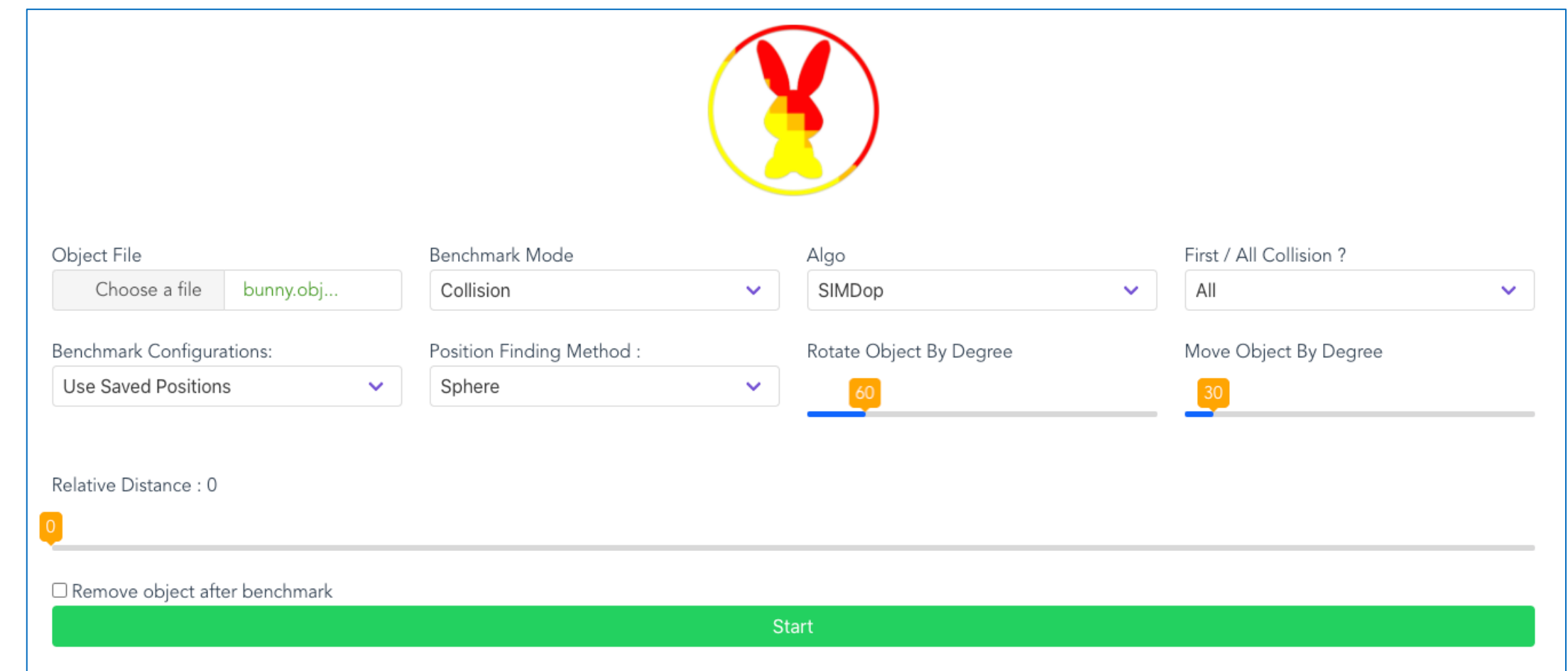
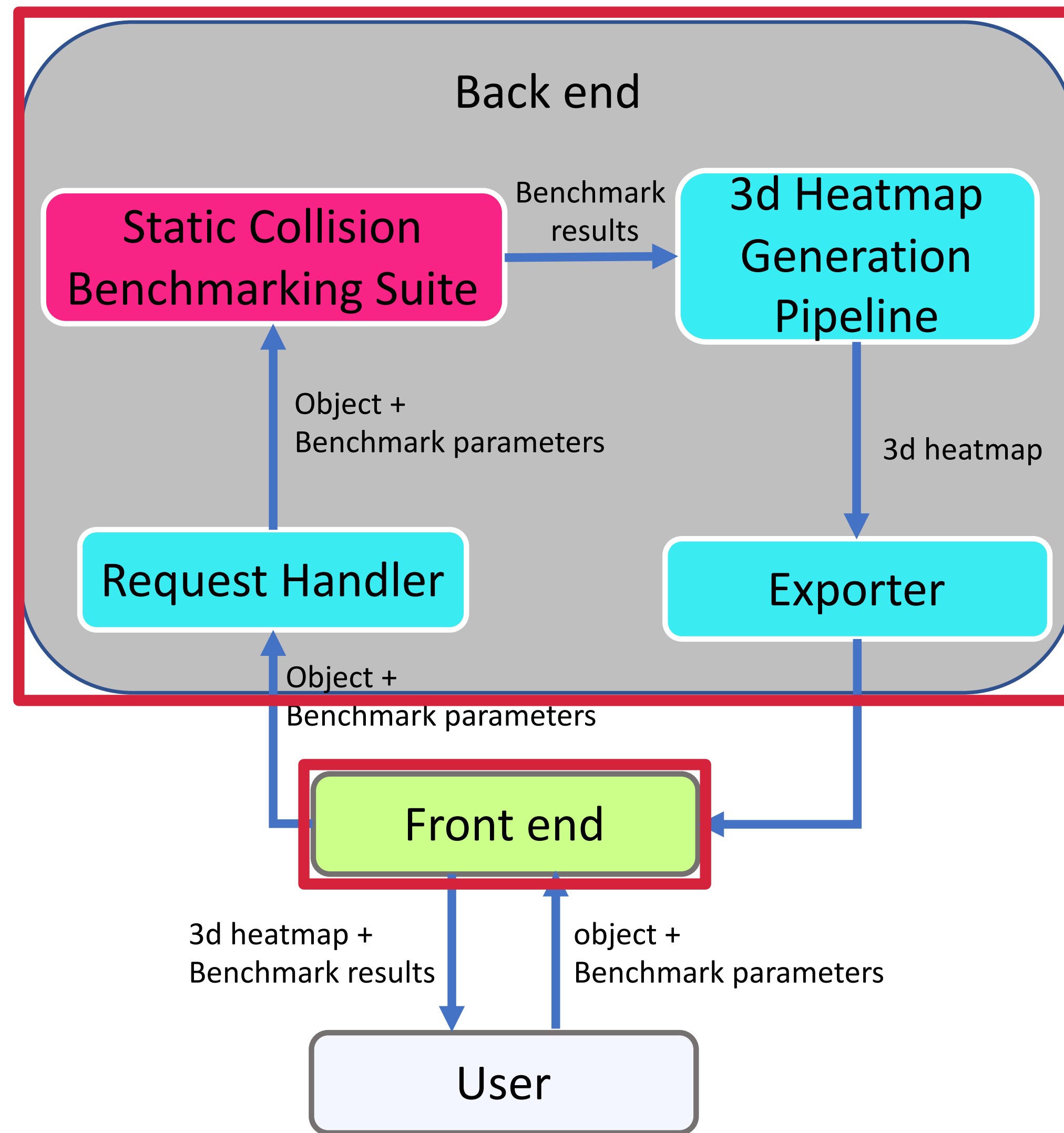
Open Benchmark - Requirements

- Reproducible and comparable results
 - Same hardware and software environment
- Easy-to-use
- Sustainability
 - New hardware or software

Benchmark as an Online Service (BOS)

For collision detection algorithms, i.e., OpenCollBench [Tan et al. 2019]

BOS: OpenCollBench

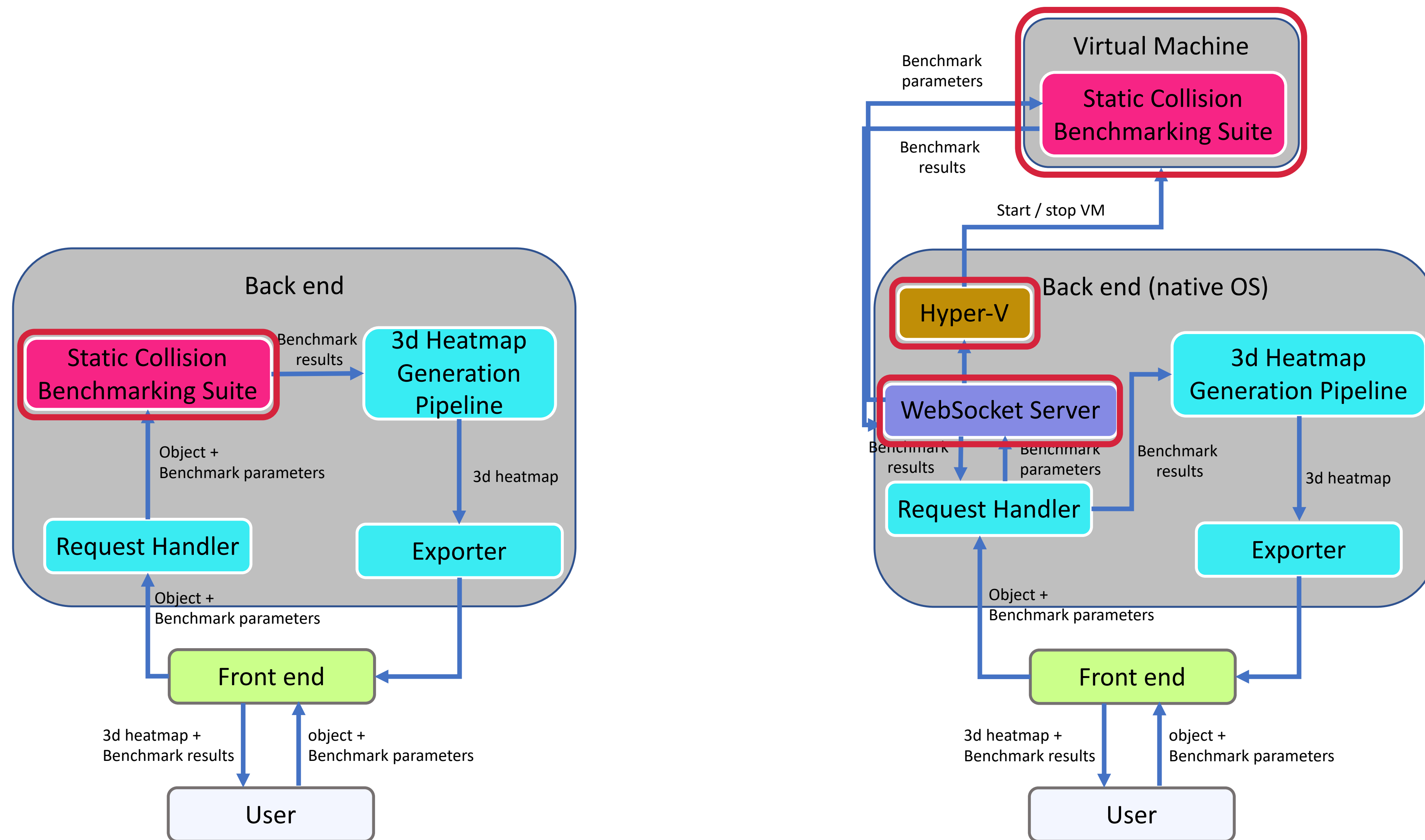


BOS Challenge: Integration of New Algorithms

- New algorithms as wrapper *Dynamic Link Library* (DLL)
- Risk of running unknown user-uploaded code
 - Analyzing and validating code is not trivial
- Manual integration is time-consuming & problematic
 - e.g., in work-in-progress development or non-disclosure agreements.

Guarantee **security** as well as **reproducibility** and **comparability** of BOS by executing user-uploaded algorithms in virtualization environment

OpenCollBench: Extended System Overview



OpenCollBench: Extended System Overview

- Hyper-V supports SIMD (AVX-512) and GPU passthrough
 - Required by CD algorithms, i.e., simdop
- Run 1 VM at one time
 - Comparability
 - Avoid users from overloading host system
- VM always start from initial state
 - Prevent system changes by OS or previous algorithms

OpenCollBench: Demo

Hyper-V Manager interface showing a virtual machine named 'BenchmarkVm' with state 'Off'. The interface includes a table of virtual machines, a list of checkpoints, and detailed information for the selected VM, such as creation date (10/17/2022 2:13:15 PM) and configuration version (9.0).

OpenCollBench: Benchmarking of Collision Detection & Proximity Queries as a Web-Service. The interface features a bunny logo and various configuration options:

- Object File: Choose a file / Please upload file
- Benchmark Mode: Collision
- Algo: SIMDop
- First / All Collision?: All
- Benchmark Configurations: Use Saved Positions
- Position Finding Method: Sphere
- Rotate Object By Degree: 60
- Move Object By Degree: 30
- Relative Distance: 0
- Remove object after benchmark
- Start button

```

Toni@DESKTOP-UTHIE60 MINGW64 ~/Desktop/backend (jan-eric-ba)
$ node vmBenchmarkServer.js

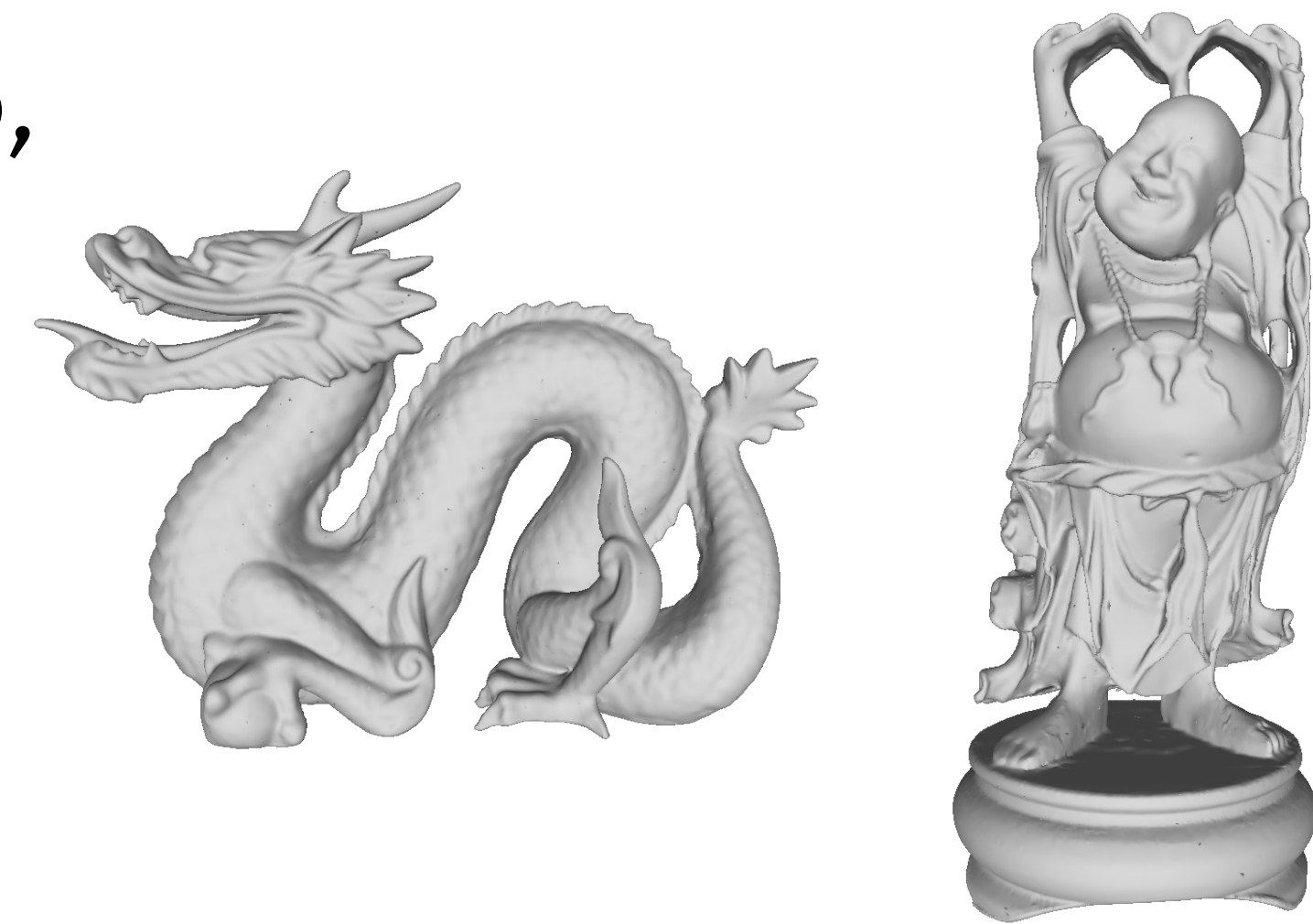
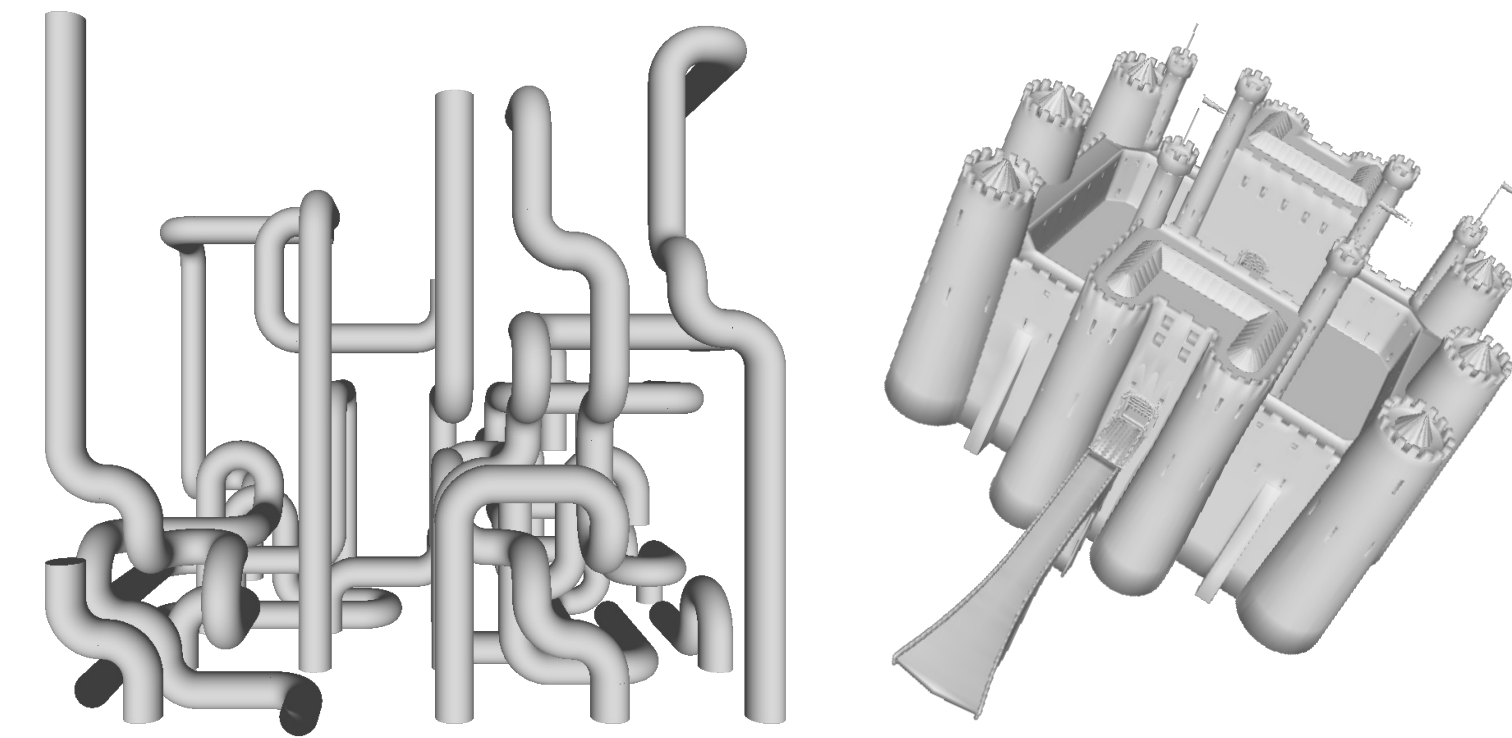
MINGW64/c/Users/Toni/Desktop/backend
Toni@DESKTOP-UTHIE60 MINGW64 ~/Desktop/backend (jan-eric-ba)
$ |
    
```

Benchmark Results: Reliability

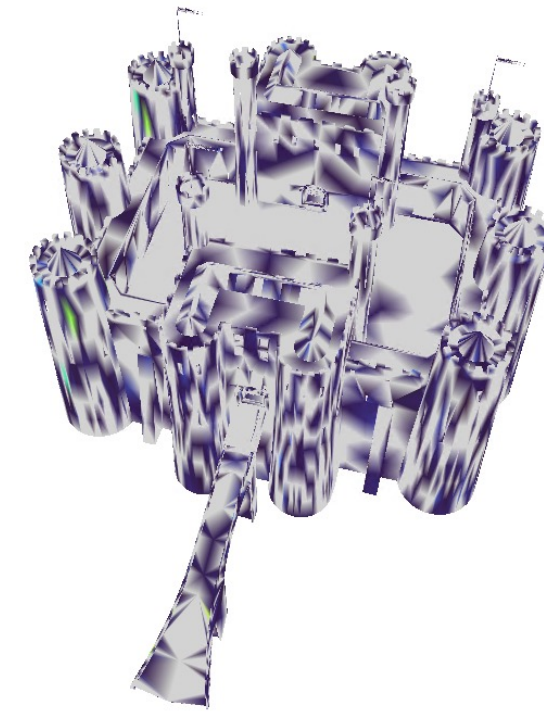
Is the benchmark results **reliable**?

Benchmark Setup

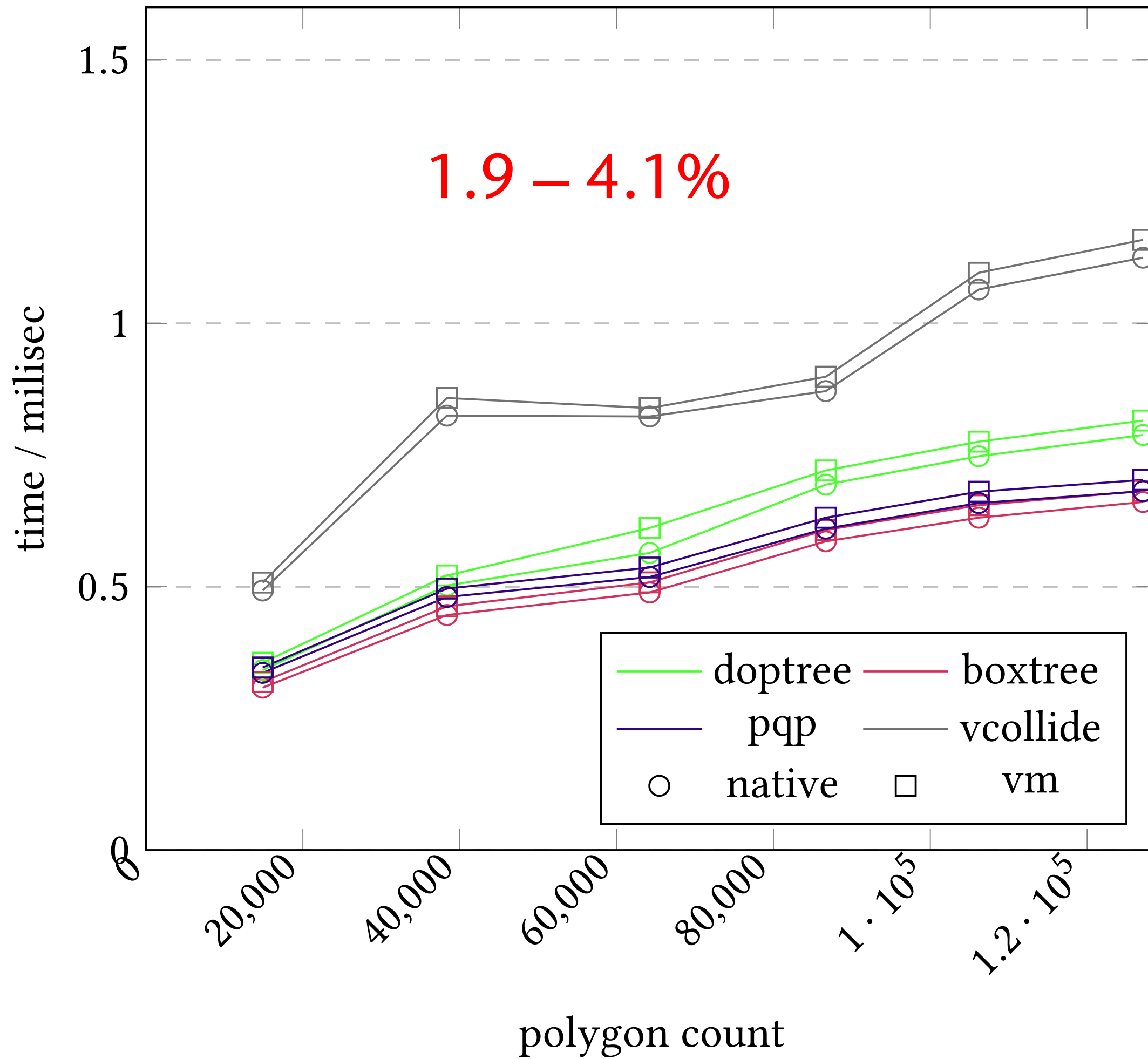
- Benchmark in native and vm
- Objects with various polygon count from 10k to 120k
- Ca 200k different configurations at distance 0.0
 - Up to 20 minutes to finish
- Common CD algorithms, e.g., doptree, boxtree, pqp, vcollide, and simdop



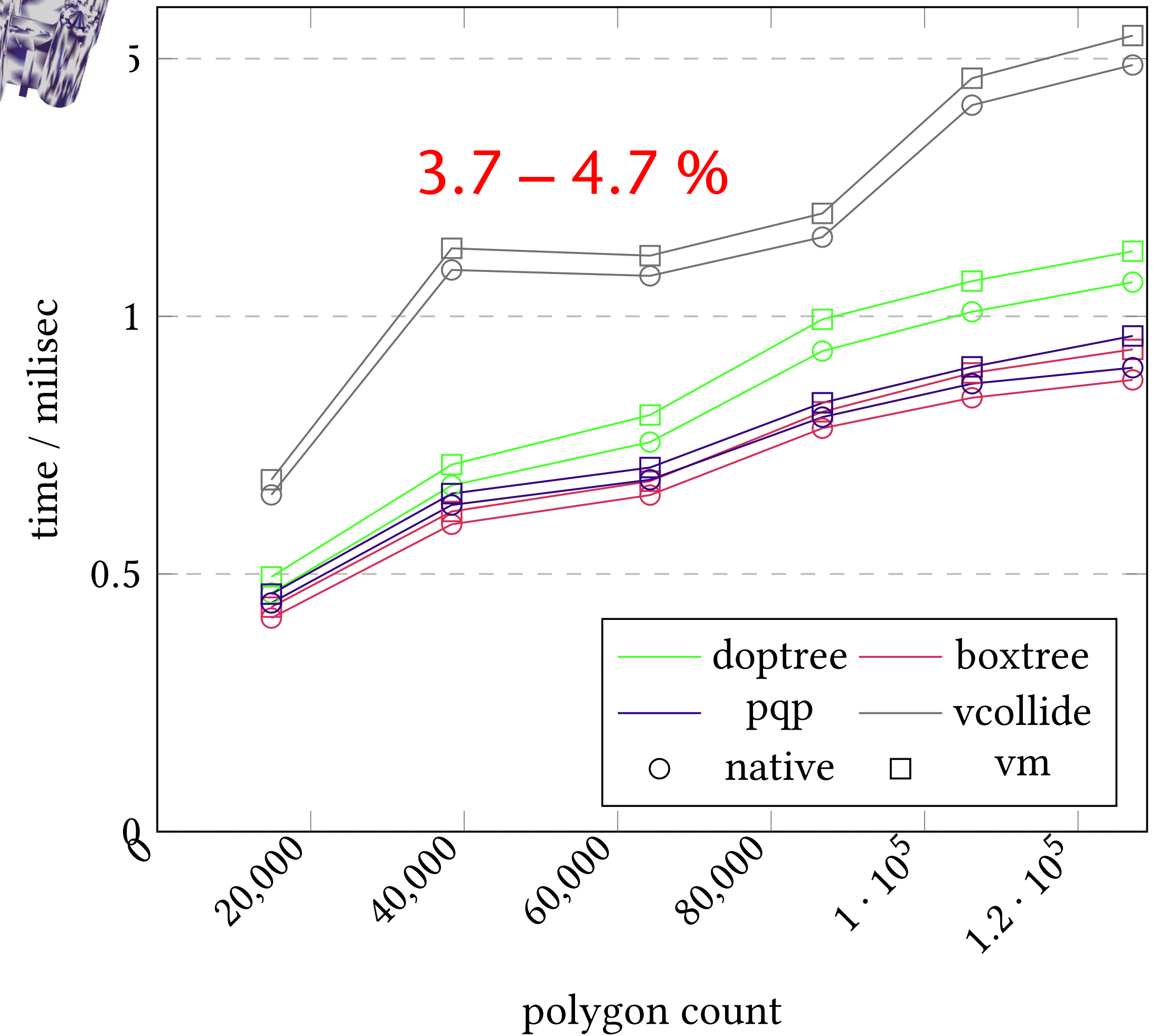
Results: Native vs VM (Different CPUs)



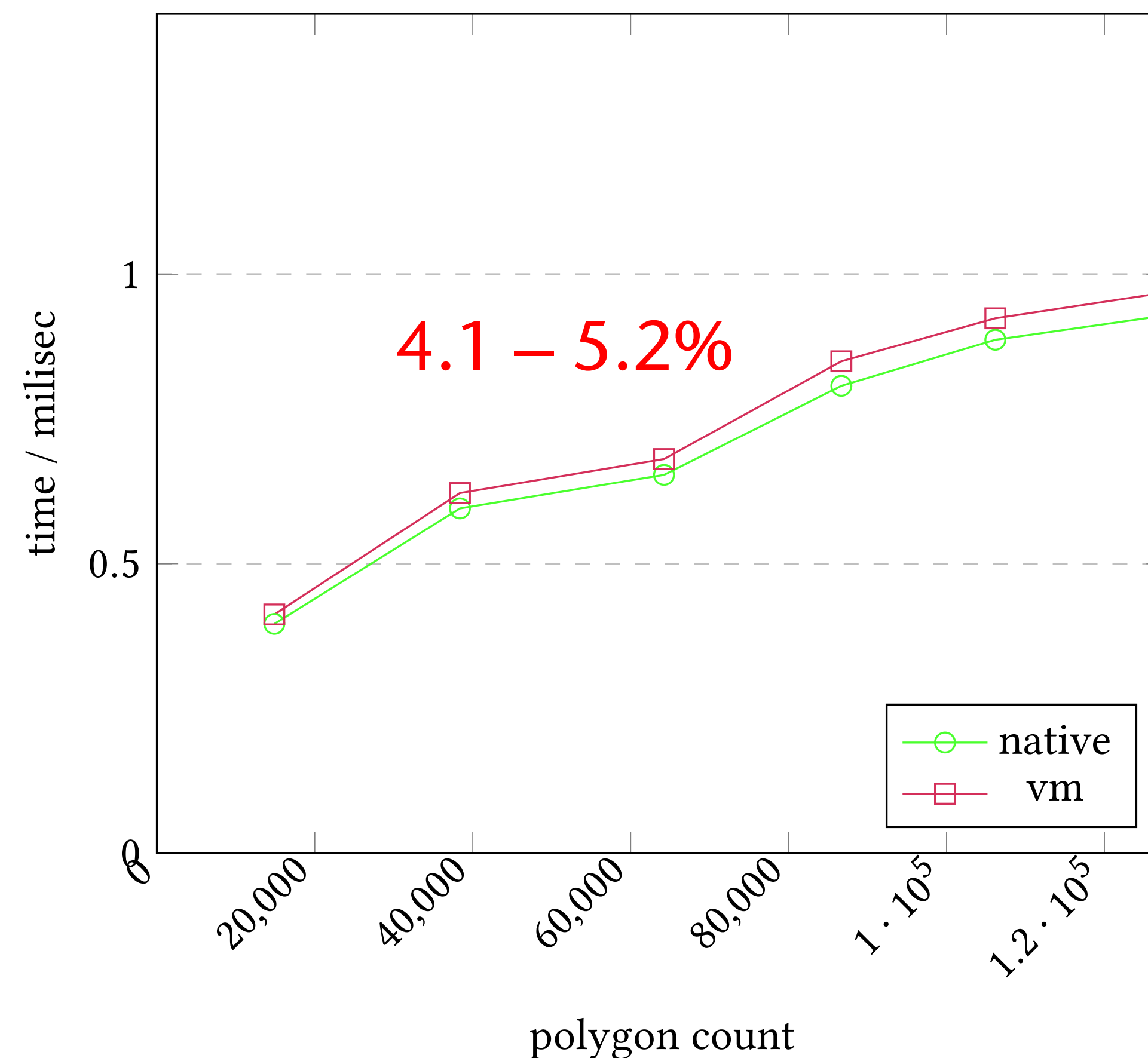
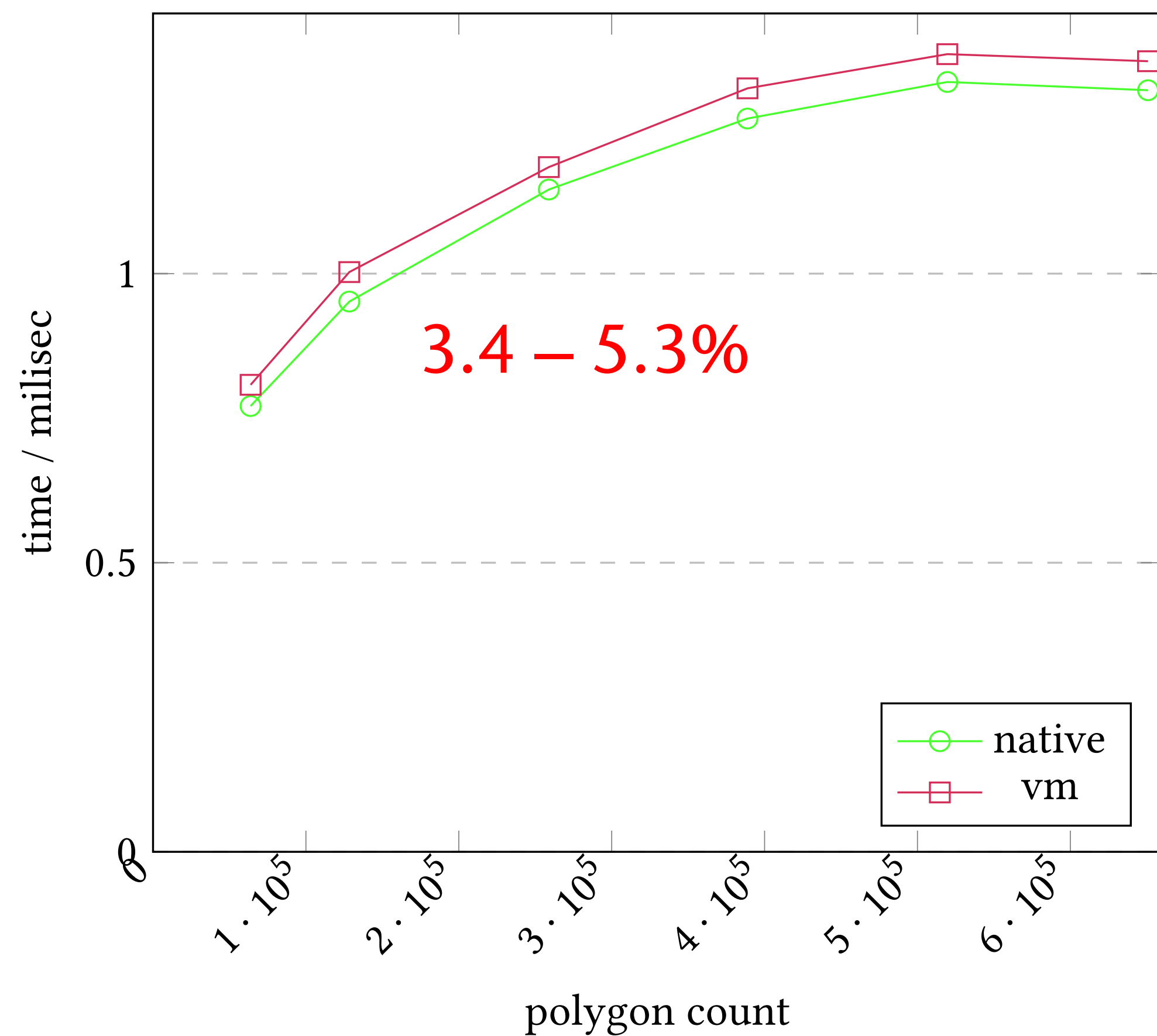
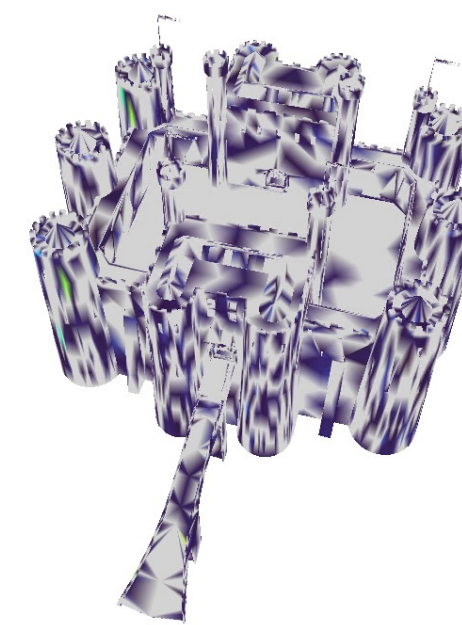
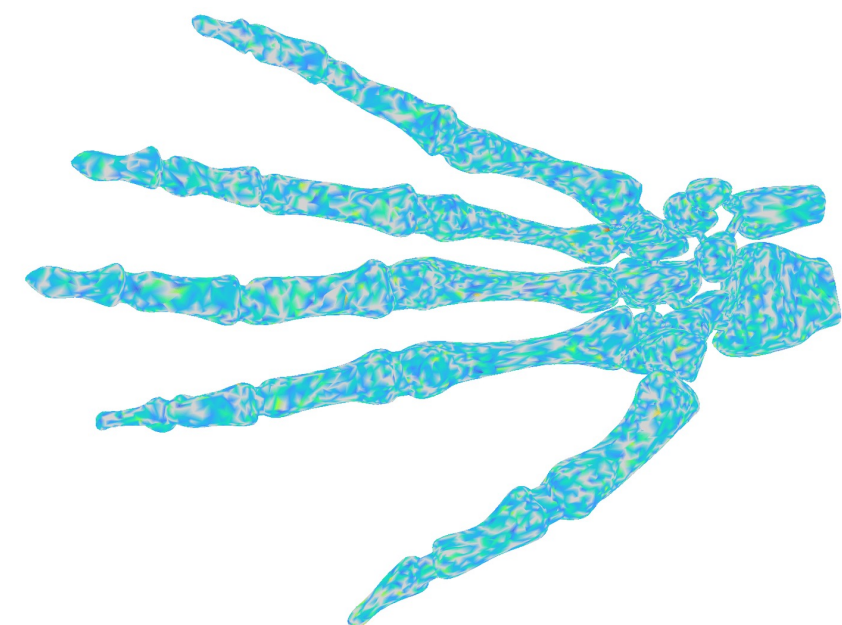
AMD Ryzen 9 3900X (3.8 – 4.6 GHz)



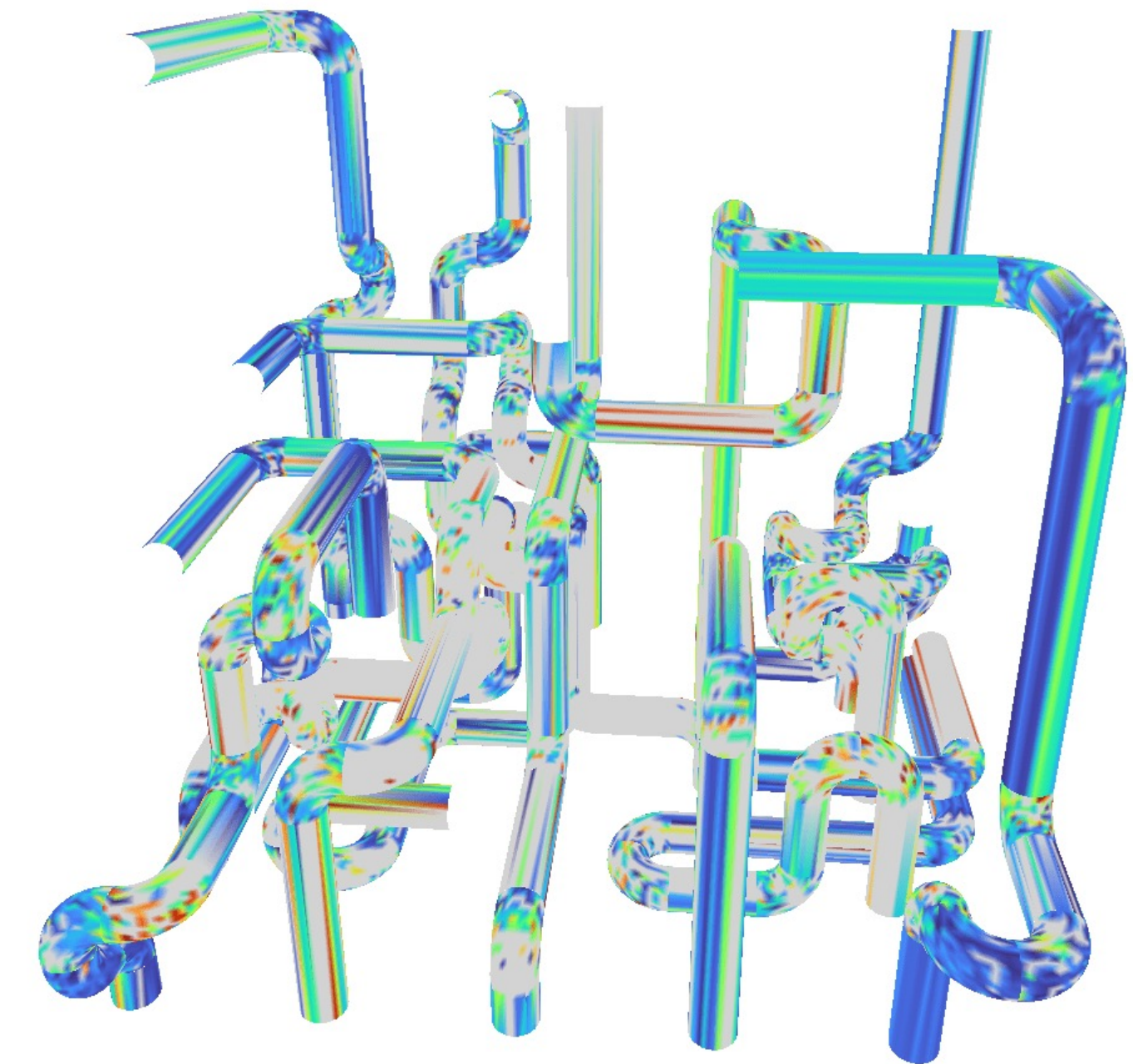
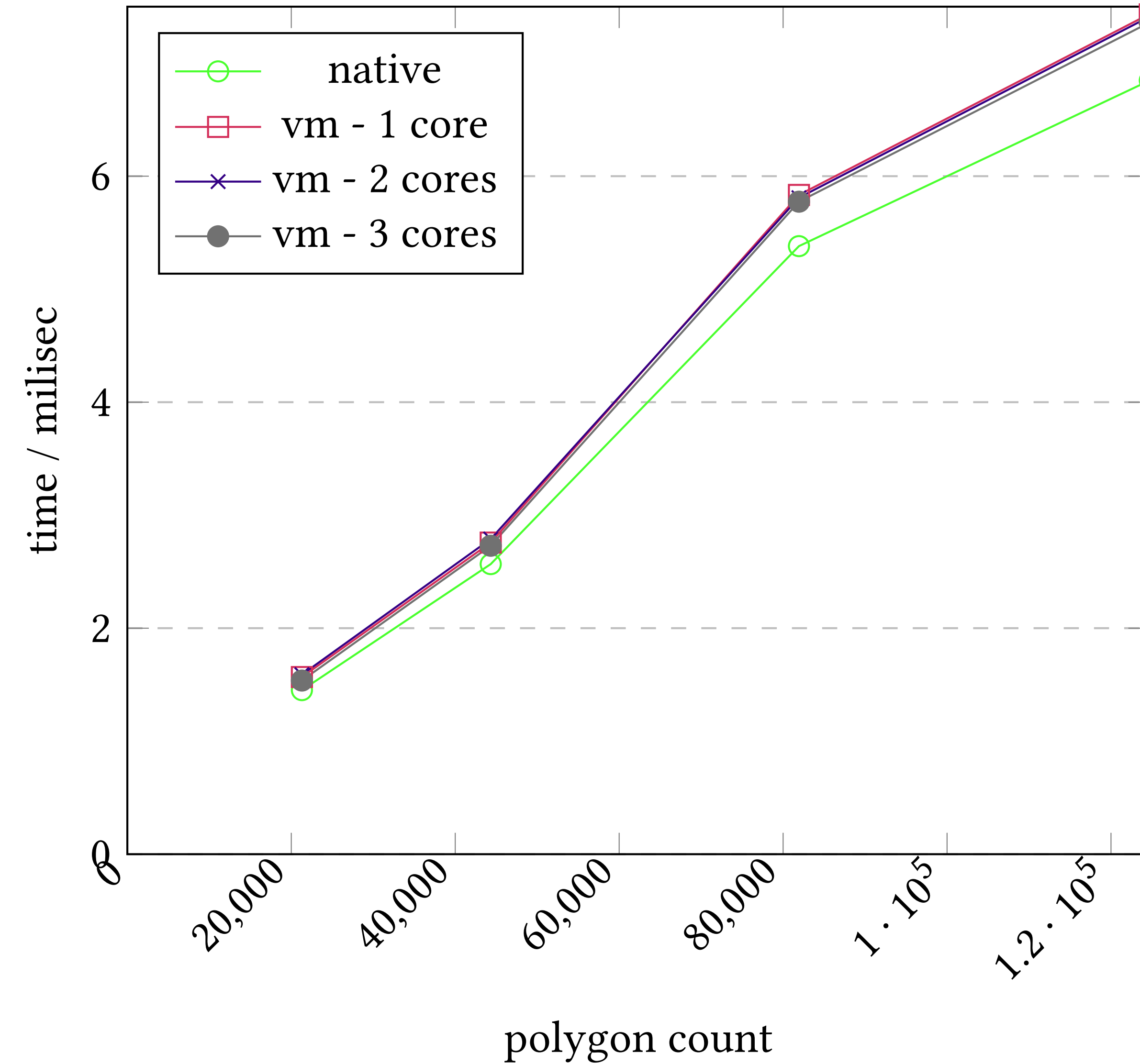
Intel i7 7800X (3.5 – 4 GHz)



Results: SIMD (AVX-512) Performance In SIMDop

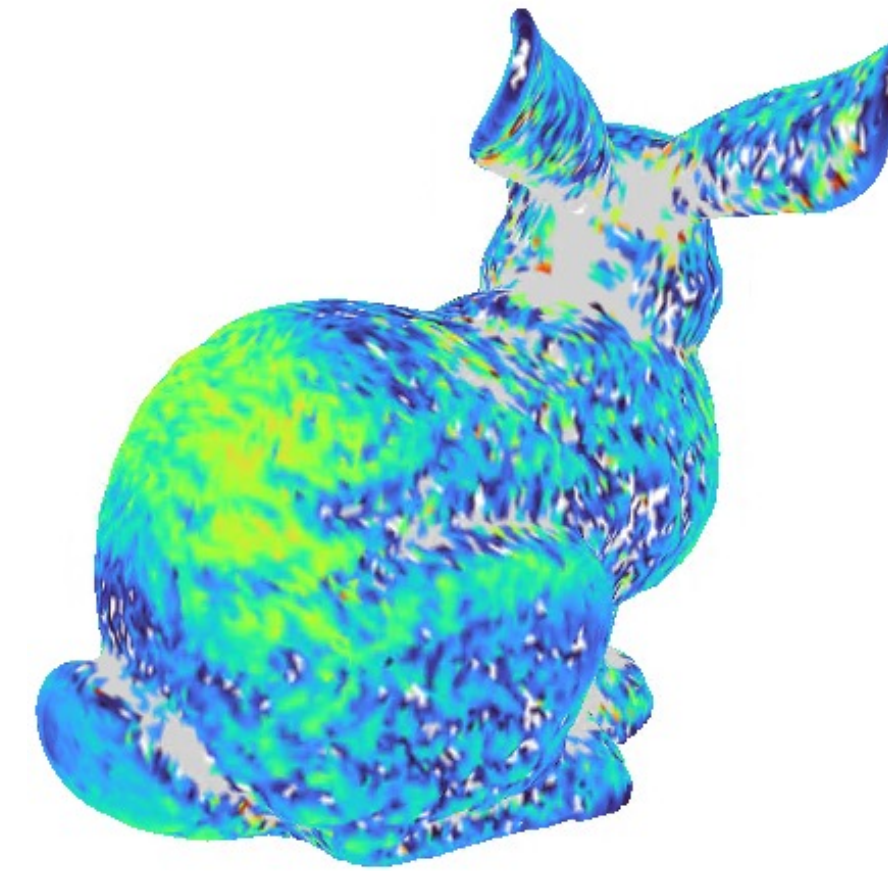
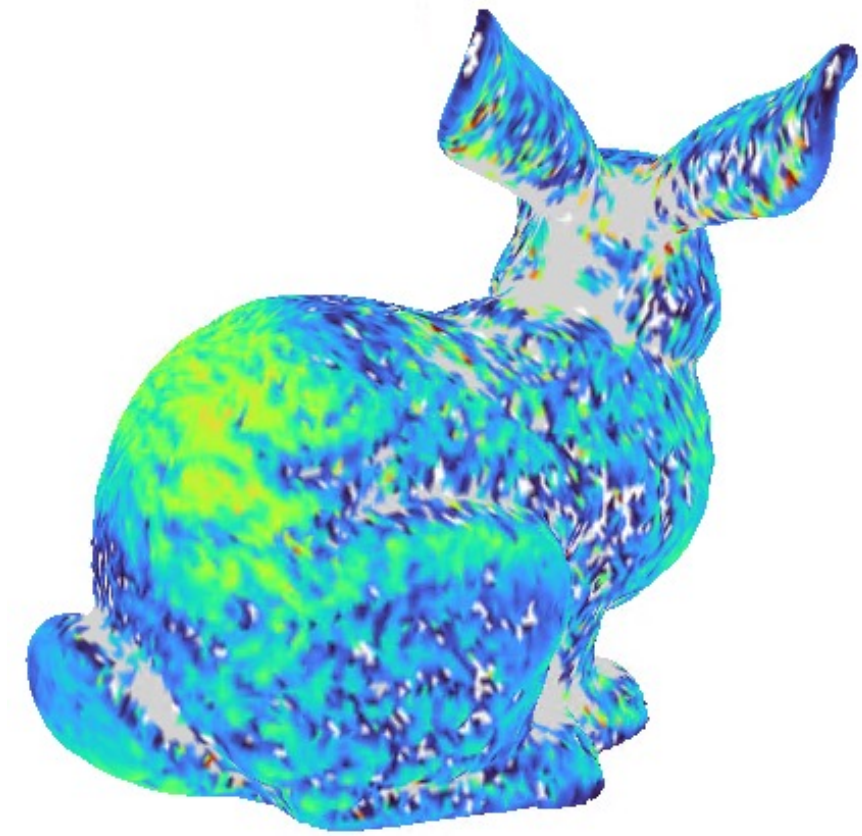


Result: VM with Different CPU Cores



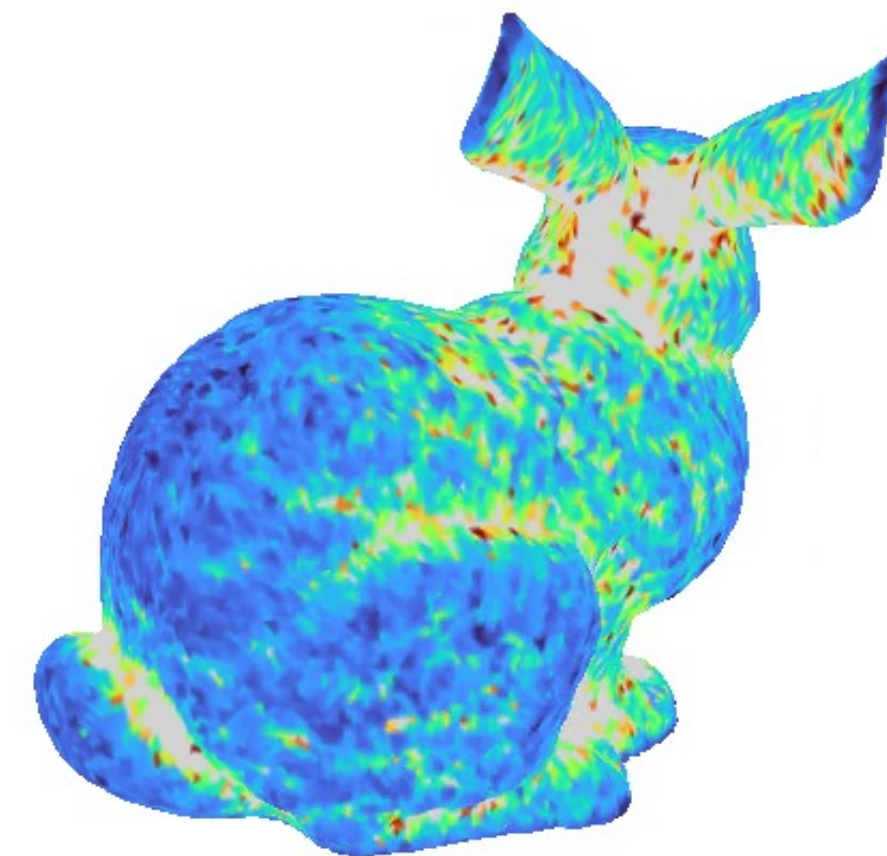
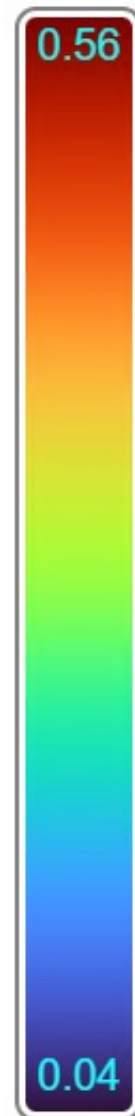
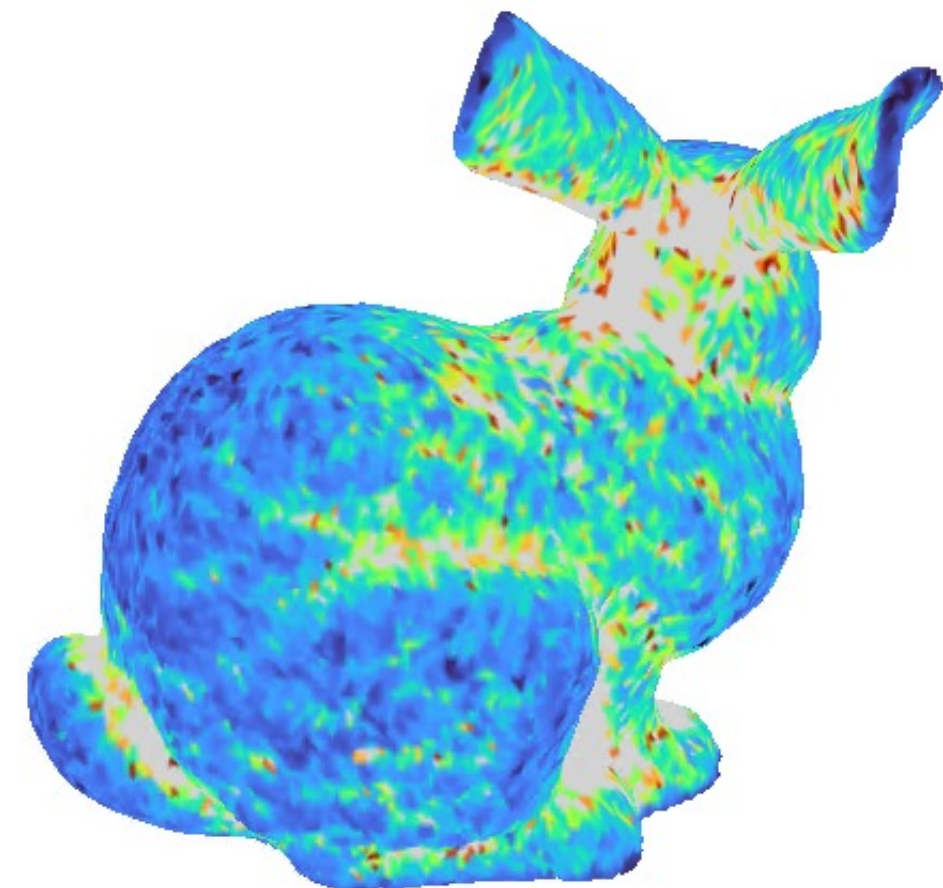
Result: Heatmap Comparison (Boxtree & Vcollide)

Boxtree (native)



Boxtree (vm)

Vcollide (native)

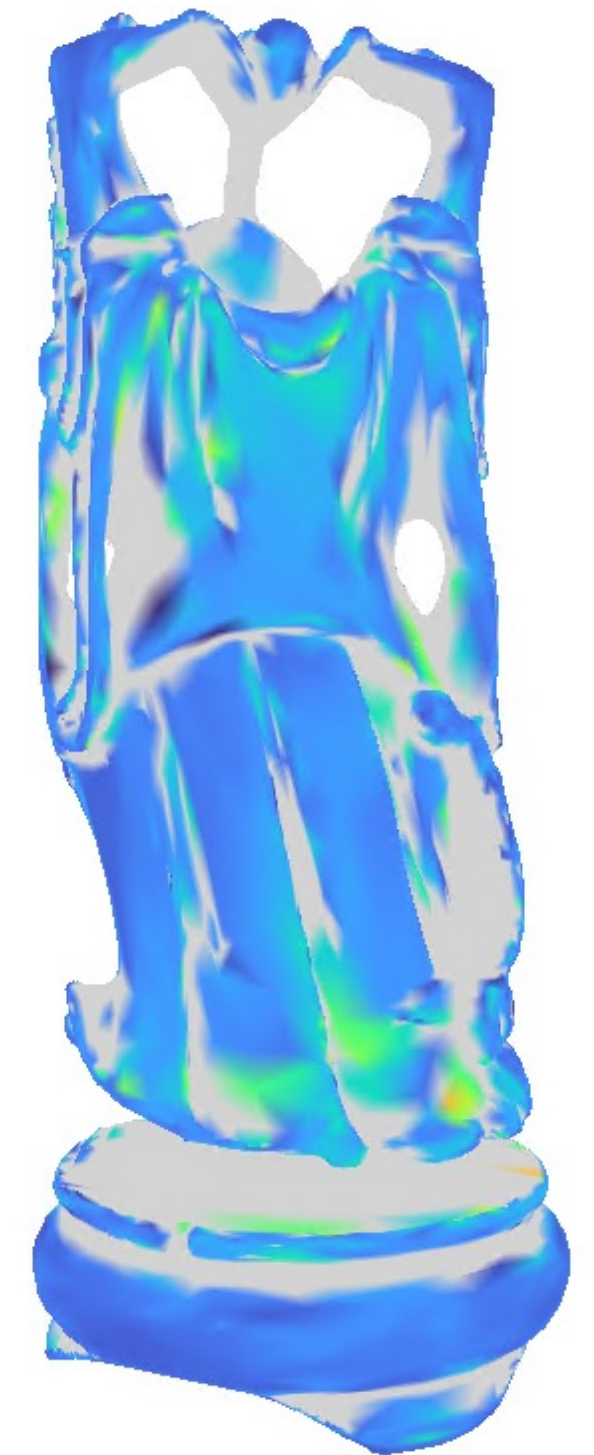
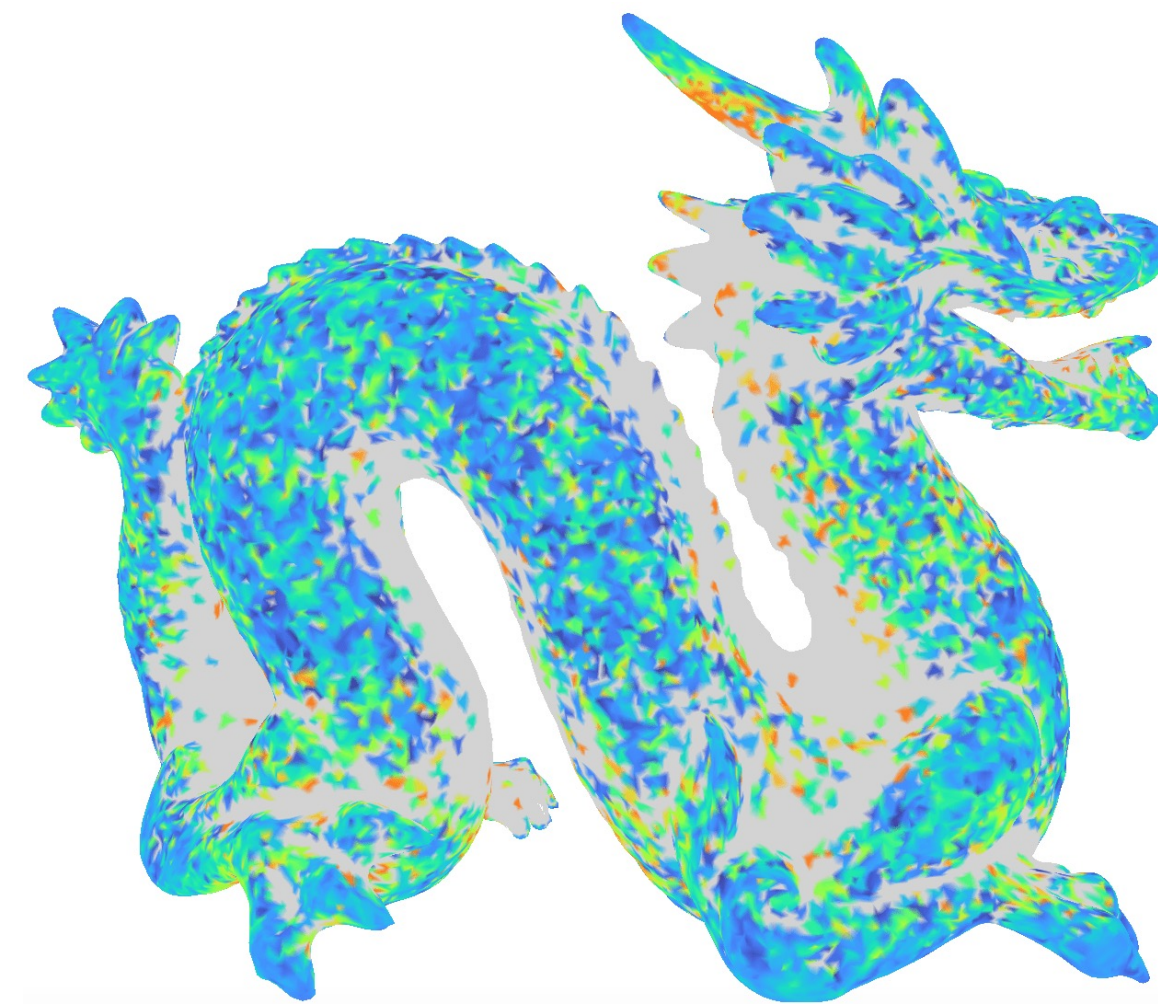
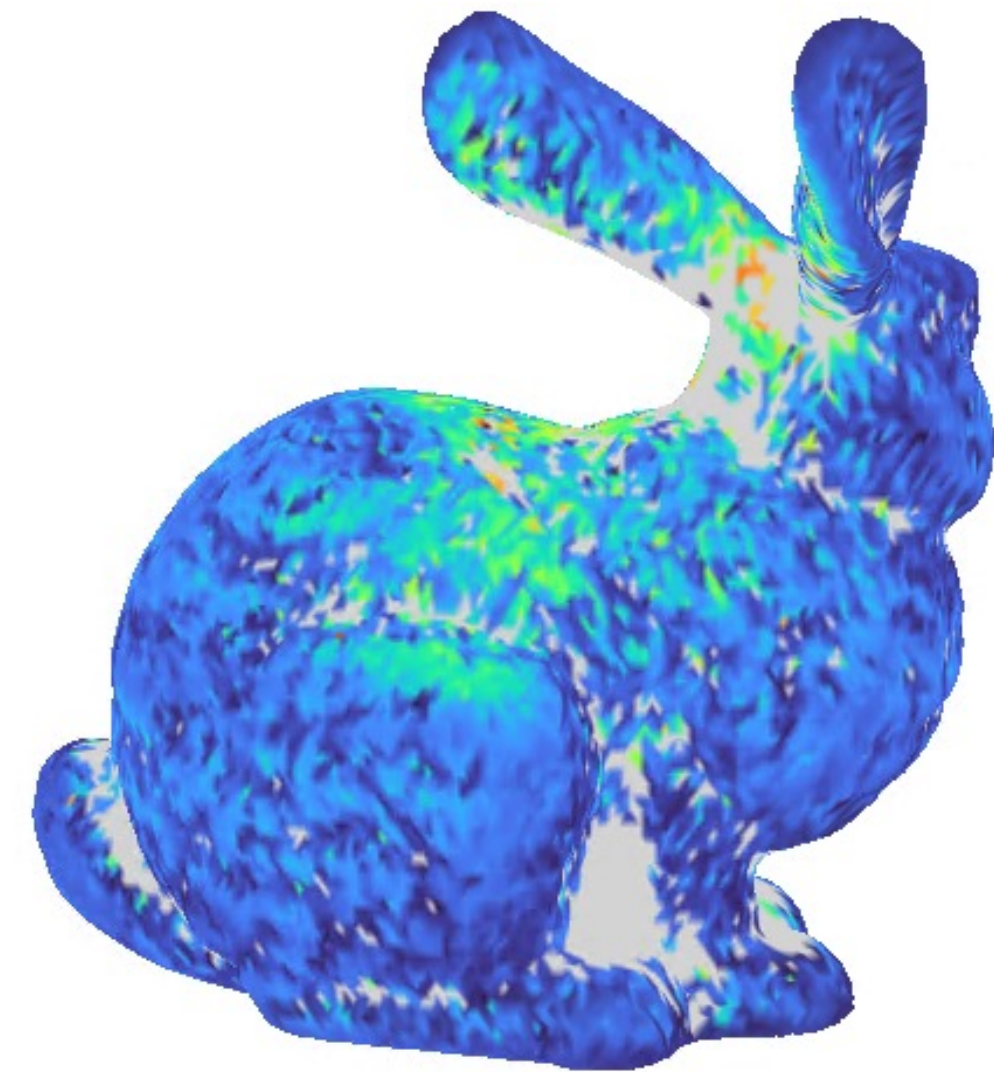
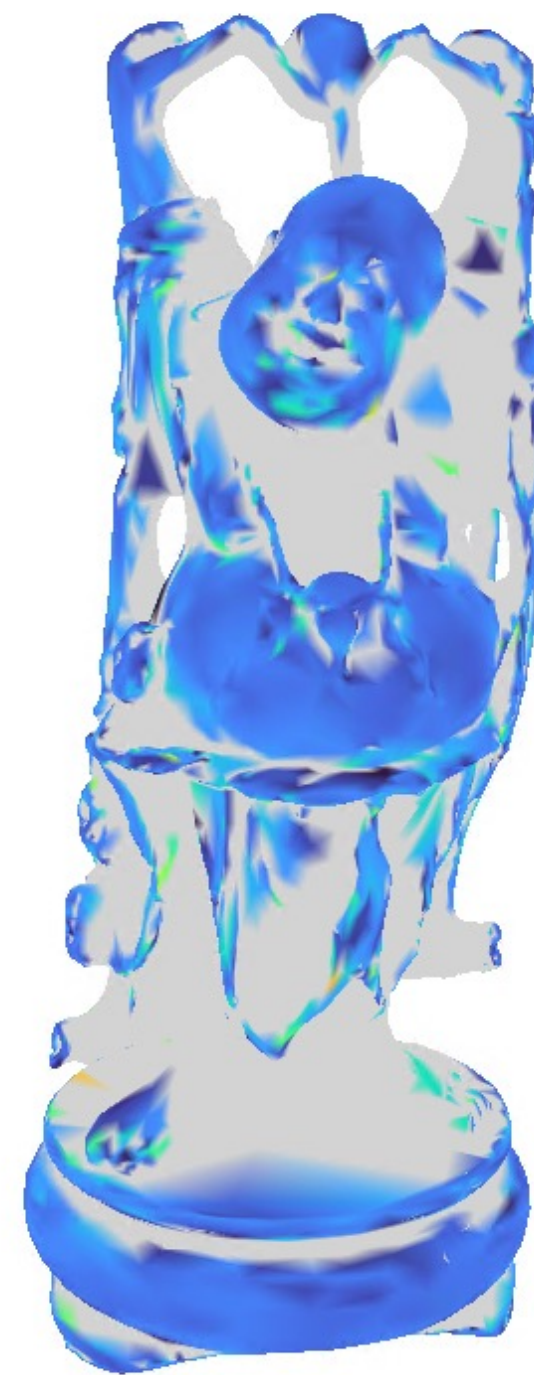


Vcollide (vm)

Conclusions

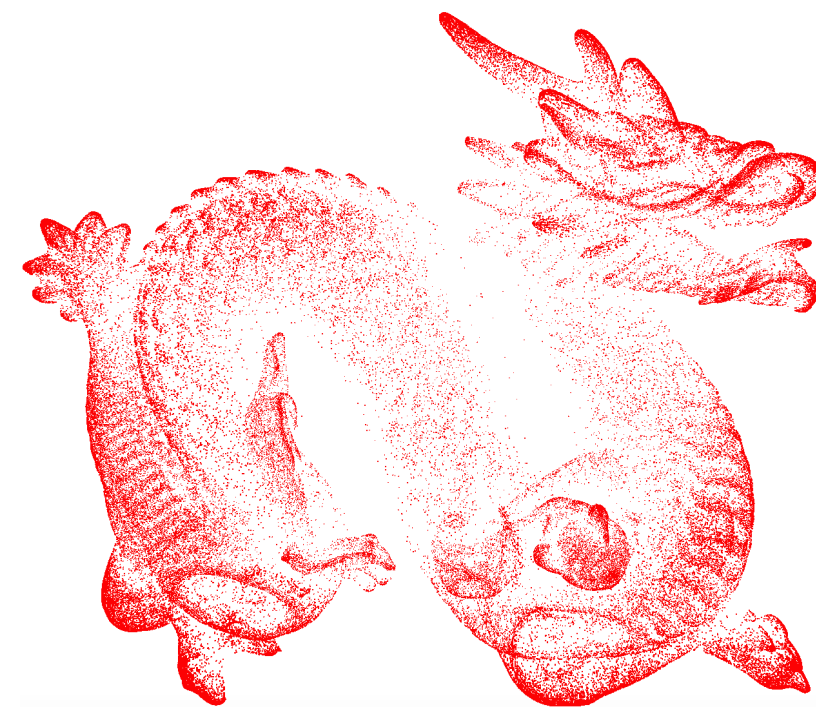
- A framework for the secure execution of user-uploaded algorithms in virtualization environment for BOS
- The entire process is automated and implemented on top of existing BOS Framework, i.e., OpenCollBench
- Benchmark results are reliable
- Future work:
 - Implementation of REST endpoint
 - Automatic benchmark within continuous integration pipeline, or
 - As a plugin for IDE to directly assess effects of change in algorithms during development

Thank You!



Toni Tan, René Weller, Gabriel Zachmann

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



- Bonneel, Nicolas, David Coeurjolly, Julie Digne, and Nicolas Mellado. "Code replicability in computer graphics." *ACM Transactions on Graphics (TOG)* 39, no. 4 (2020): 93-1.