MIARFID
Official Master's Degree in Artificial Intelligence, Pattern Recognition and Digital Imaging

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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DEPARTAMENTO DE SISTEMAS INFORMÁTICOS Y COMPUTACIÓN

Comparison of Ray Tracing GPU Implementations

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Universitat Politècnica de València
Dept. of Computer Systems and Computation

Master's Thesis
Master's Degree in Artificial Intelligence, Pattern Recognition and Digital Imaging

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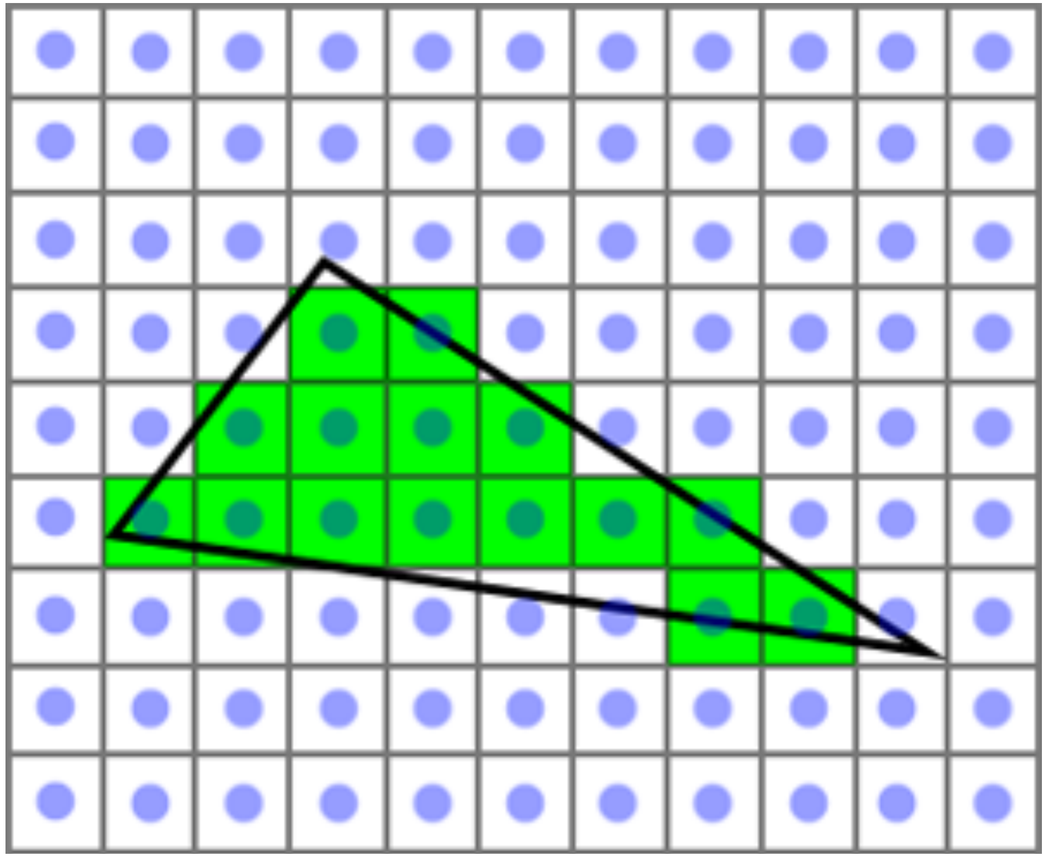
Contents

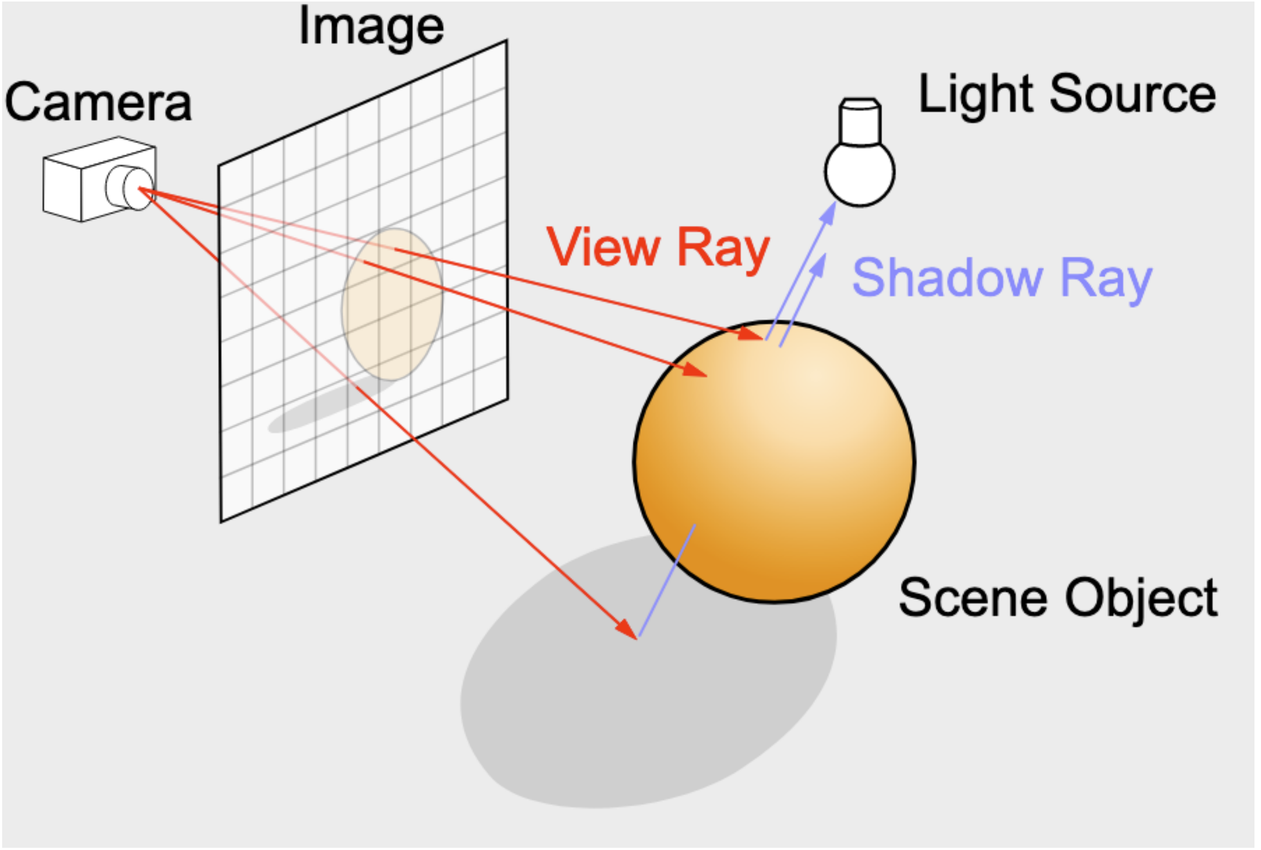
Problem and Objectives

- Ray Tracing is widely used in industry (film, videogames, simulation...)
- GPU acceleration is **required**
- Multiple libraries and APIs for GPU acceleration
- **Our goal:** build a benchmark comparing these technologies
  - Different scenes and rendering settings
  - Comparison in the same hardware and across different systems

State of the Art

Techniques



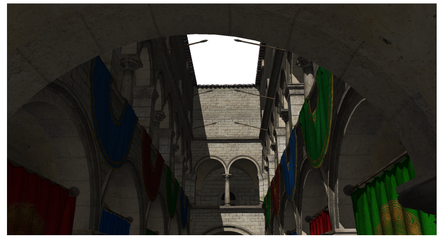


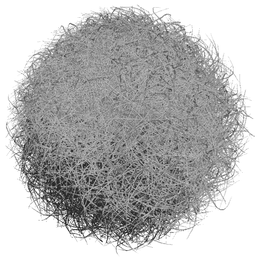
State of the Art
Technologies

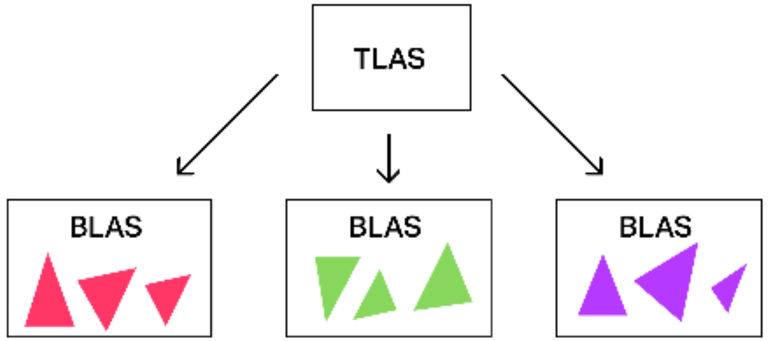
- 2 use cases: **photorealism** and **real-time graphics**
- Both require libraries to communicate with GPU for acceleration
- Nowadays main options are **OptiX** and **Vulkan** respectively

Analysis
Experiment Design

- Tracking Frame Time, Acceleration Structure (AS) Build Time and Memory Usage
- Varying screen resolution
- Different scene complexities







Model Name	Triangles	Vertices
Viking Room	2000	2600
BMW	385079	249772
Sponza	262267	184330
Hairball	2880000	1441098

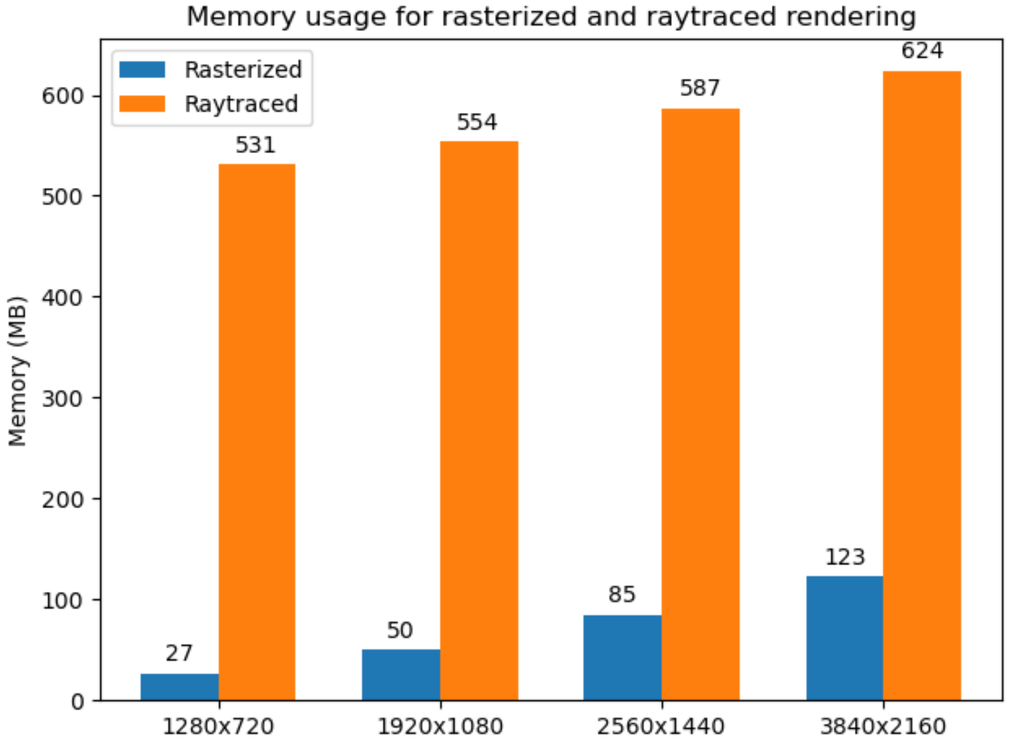
Analysis
Experiment Design

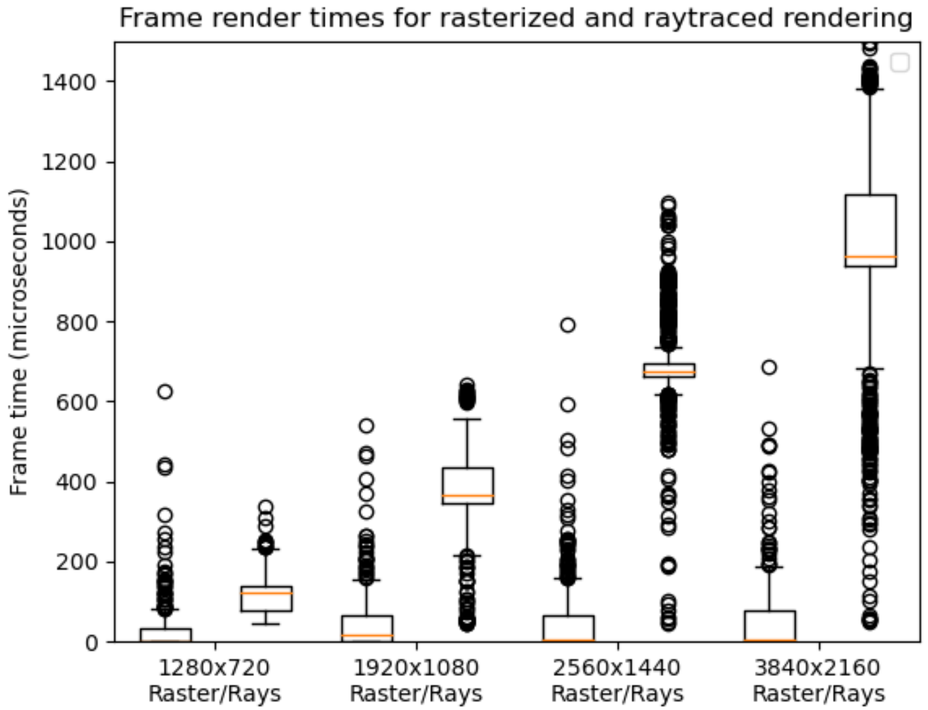
- Hardware configurations

CPU	GPU	RAM	OS
Intel Core i7-12700K, 3.60GHz	Nvidia GeForce RTX 3070	16 GB	Windows 11, 64 bit
AMD Ryzen 5 3600 3.60Hz BOX	Nvidia GeForce RTX 2070 Super	16 GB	Windows 10, 64 bit
Intel Core i5-9600K, 3.70GHz	Nvidia GeForce RTX 3060 Ti	16 GB	Windows 10, 64 bit
Intel Core i9-9900K 3.6GHz	Nvidia GeForce RTX 3080	16 GB	Virtual Machine with Linux host, Windows 10, 64 bit guest
Intel Core i7 10th gen	Nvidia GeForce RTX 3080	32 GB	Windows 10, 64 bit
AMD Ryzen 7 3800x, 3.9GHz	Nvidia GeForce RTX 2070 Super	64 GB	Windows 11, 64 bit
Intel Core i9-12900F	Nvidia GeForce RTX 2060	32 GB	Windows 10, 64 bit

Results

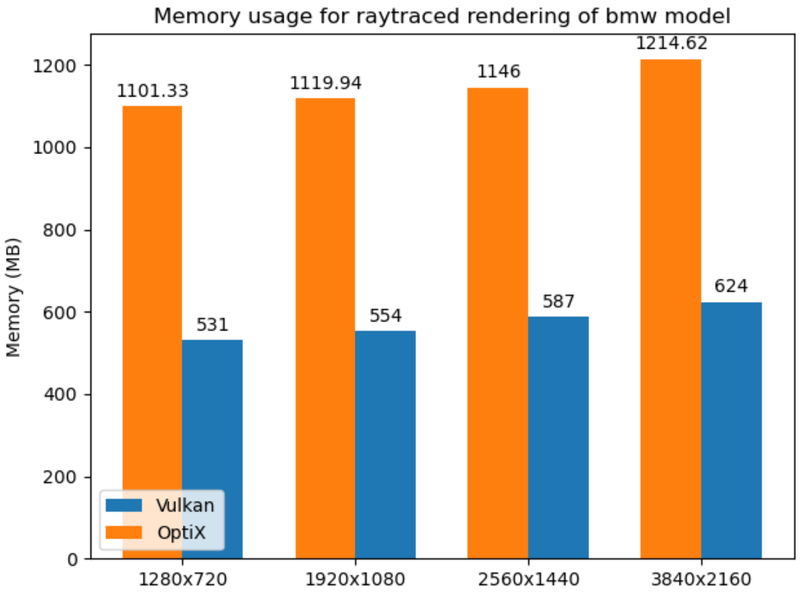
Rasterization Baseline

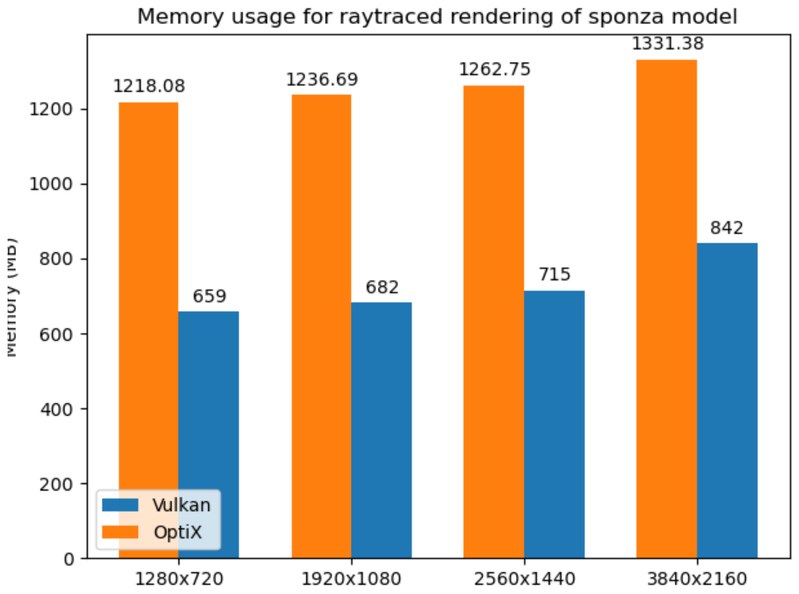


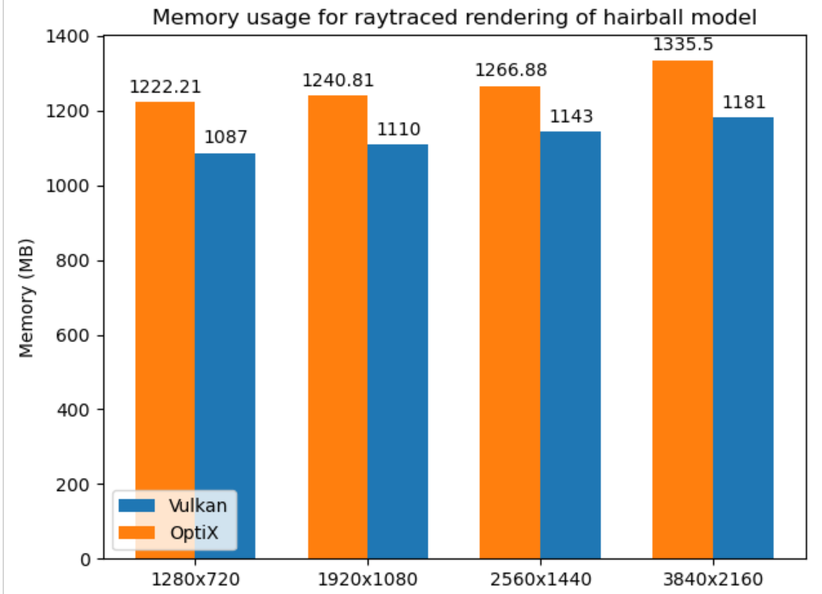


Results

Memory Usage

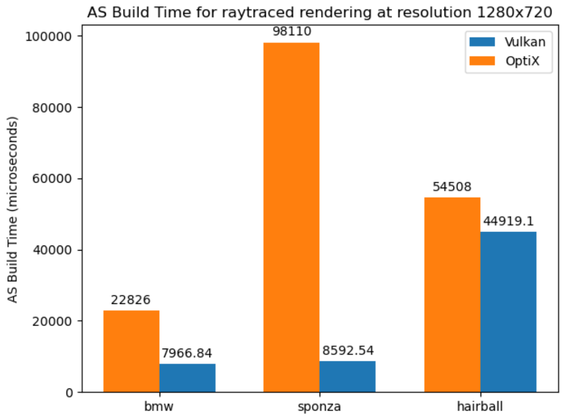


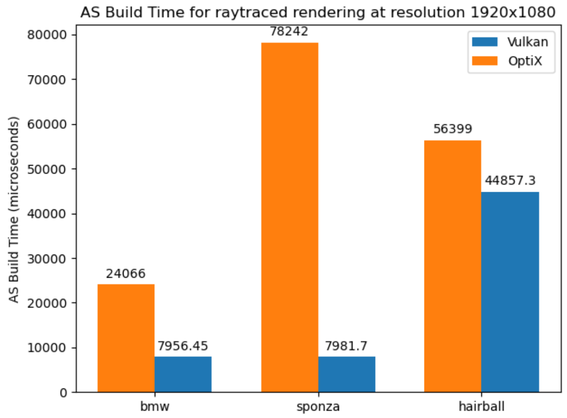


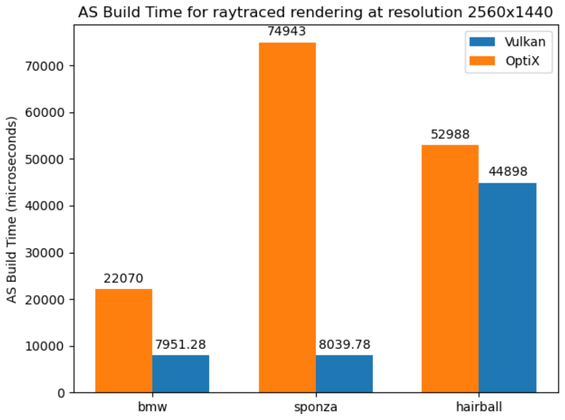


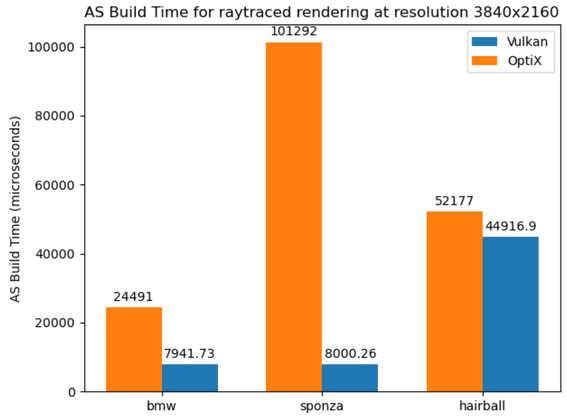
Results

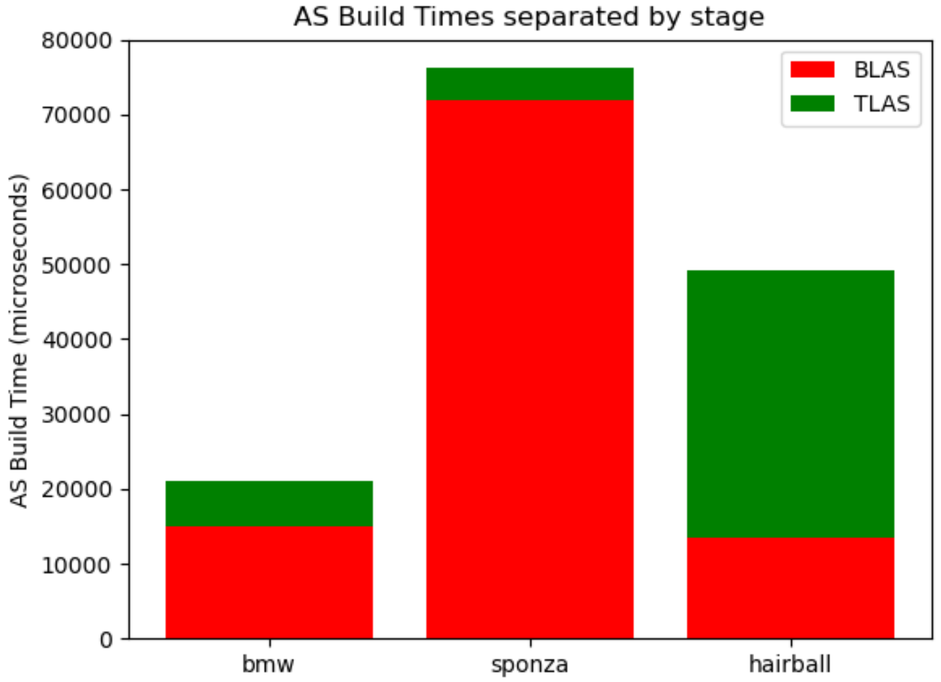
Acceleration Structure Build Time







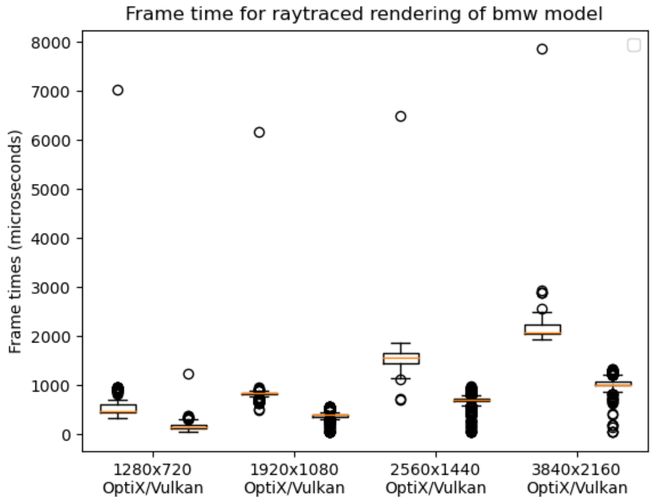


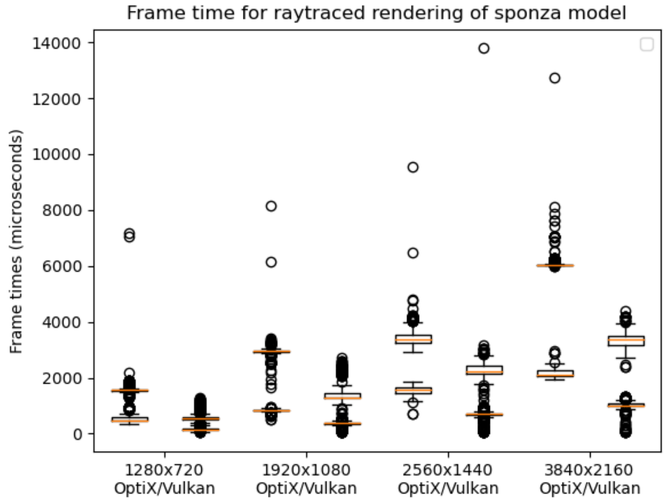


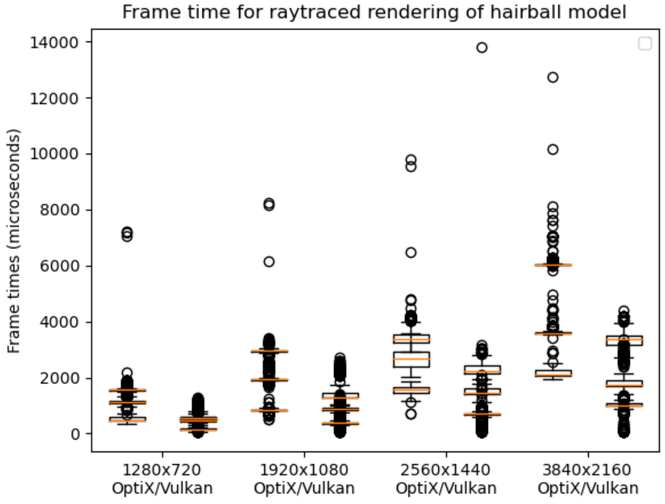
Model	BMW	Sponza	Hairball
BLAS Count	73	393	2

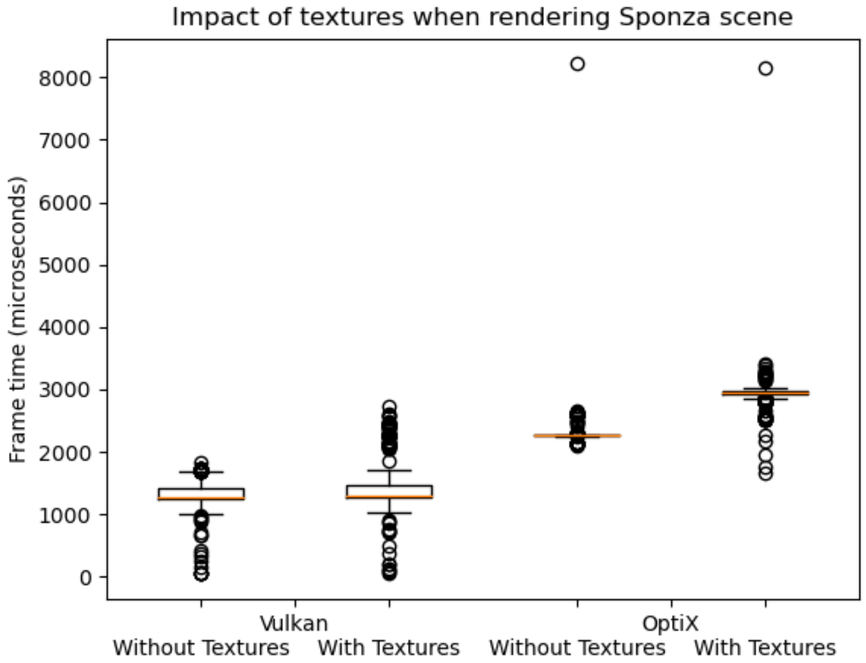
Results

Frame Render Time





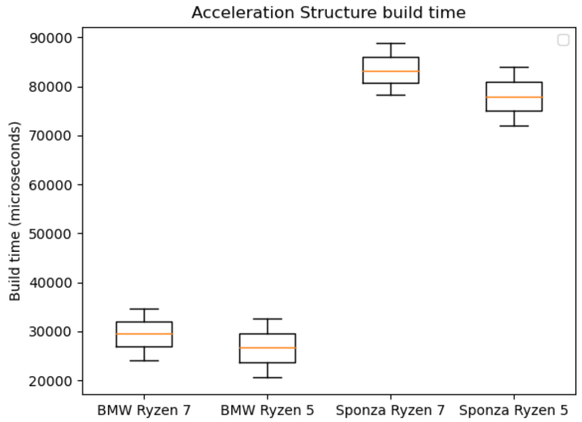


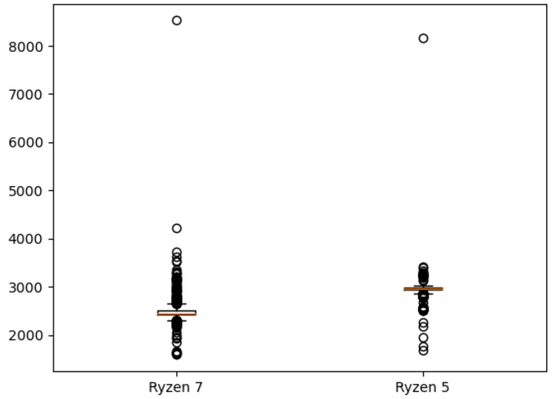


Results

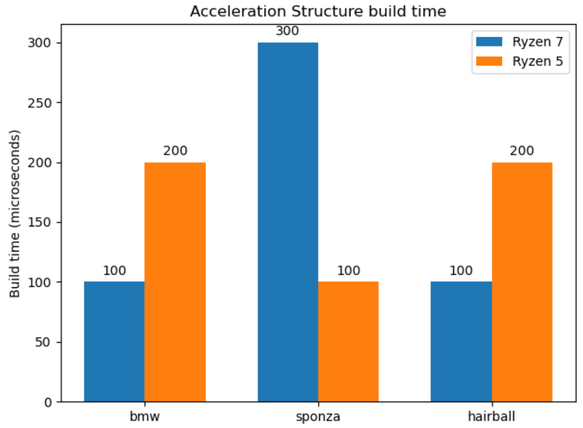
Hardware Comparison

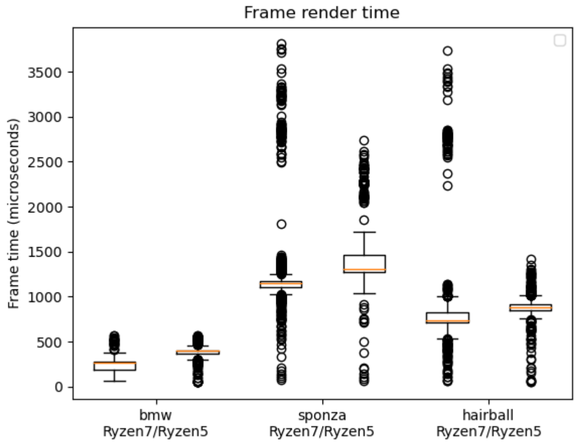
OptiX





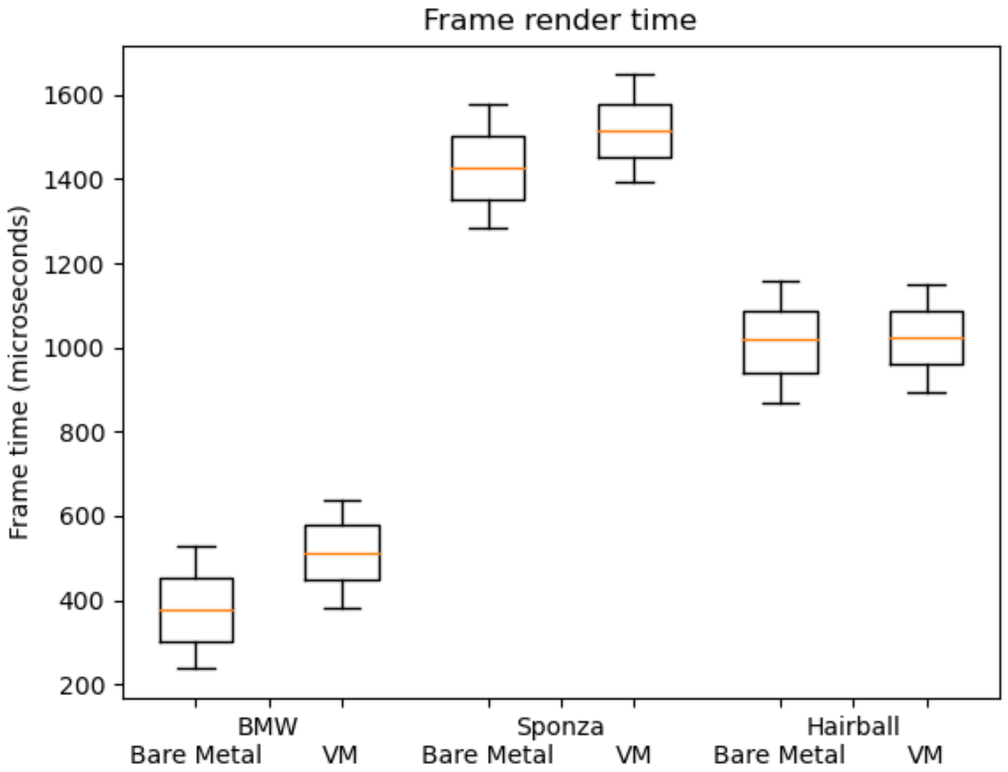
Vulkan





Results

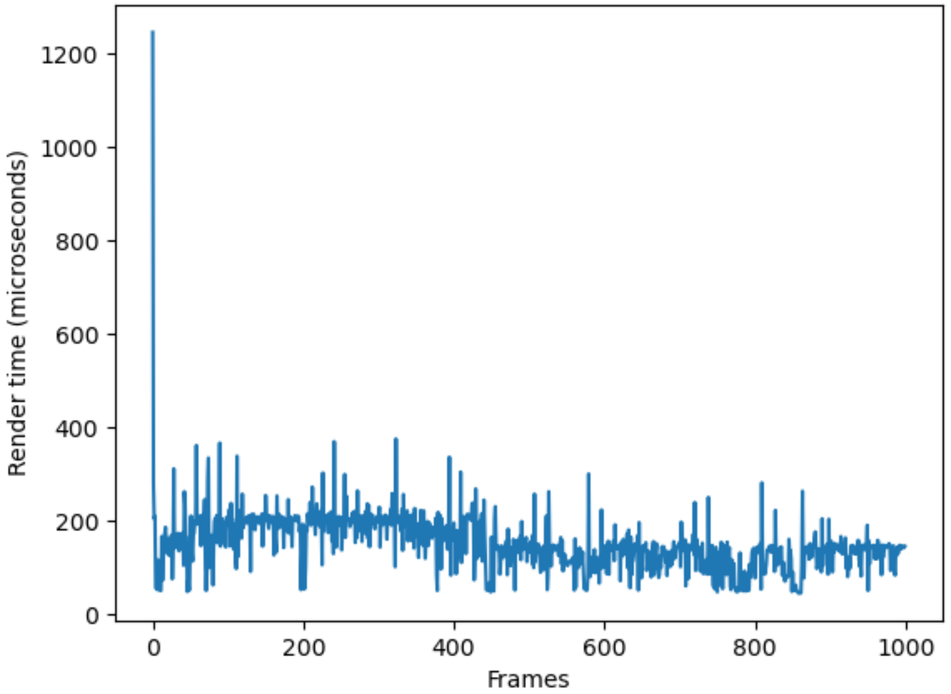
Virtualization Effects



Hardware	Bare Metal	Virtual Machine
AS Build Time (microseconds)	100	400

Results

Outlier Statistical Analysis



	Ryzen 7	Ryzen 5
Outlier percentage	41.7	31.8
Bigger than median	308	95
Smaller than median	109	223

Conclusions

Comparing Vulkan and OptiX

- Vulkan has longer development time and better performance than OptiX
- Ray Tracing is much slower than Rasterization, independently of screen resolution, sometimes by orders of magnitude
- Most tracked metrics when evaluating RT performance are render time, AS build time and memory usage

Conclusions

Comparing Vulkan and OptiX

- Vulkan’s ASBT depends largely on triangle count, while OptiX’ depends on mesh count
- OptiX’ render time is sensible to the presence of textures, while Vulkan is not
- Vulkan works without issue in a VM, while OptiX has driver issues
- Rendering is primarily GPU-bound, with the CPU being almost irrelevant

Conclusions

Future Work

- Tests with dynamic geometry
- Advanced RT implementations (reflections, other materials, etc.)
- Porting to the Nvidia Falcor framework

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