

Vulkanised 2023

The 5th Vulkan Developer Conference
Munich, Germany / February 7–9

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Platinum Sponsors:



Virtual reality-based visualization of large scientific data

Outline

□ Motivation

□ Results

□ Extensions

Visualization

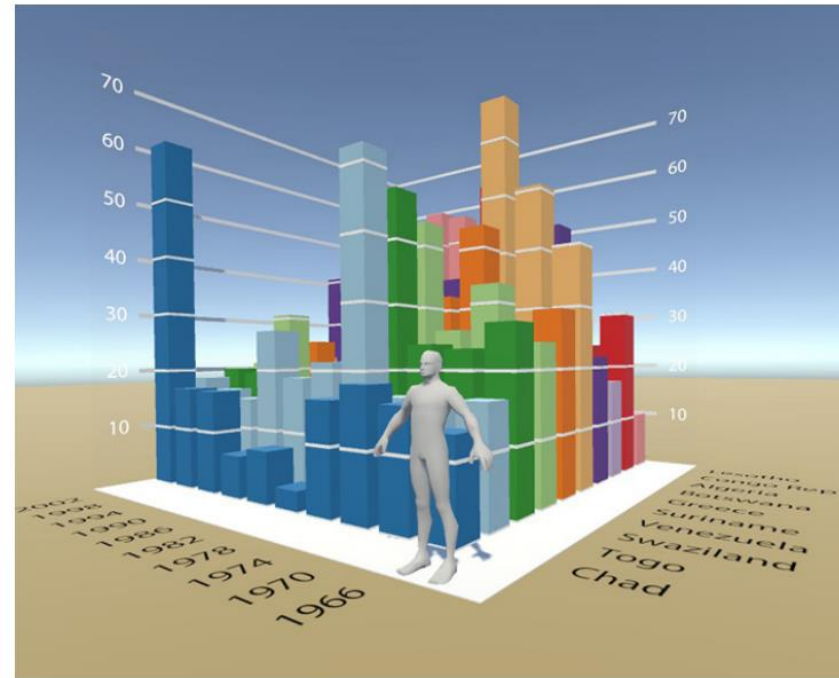
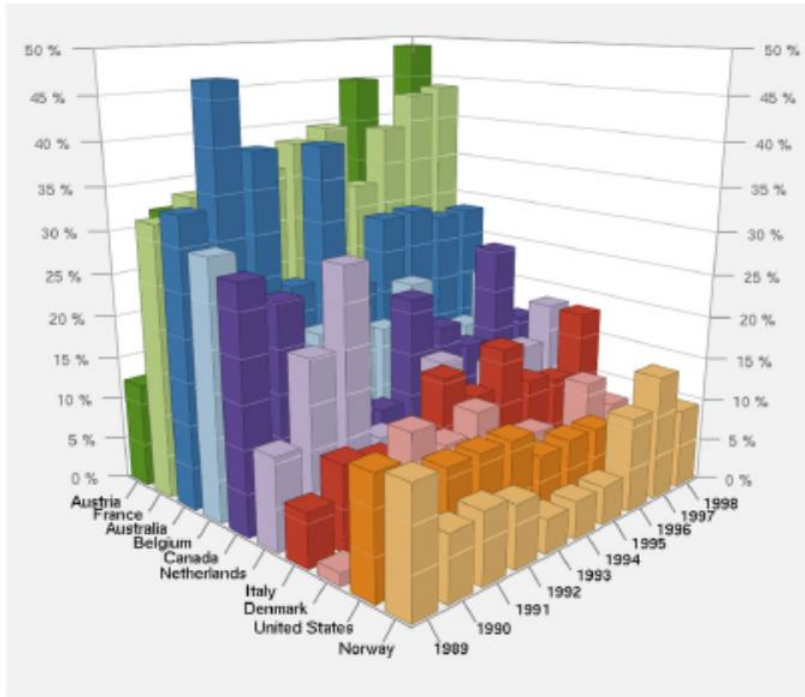
- Integral part of the scientific method
- Helps exploring and understanding data
- **Inspection:**

the act of [looking](#) at something [carefully](#), or an official visit to a building or organization to check that everything is correct and legal

- **Interaction:**

an occasion when two or more people or things [communicate](#) with or [react](#) to each other.

Being “In” the Data



Large Datasets warrant new inspection modalities



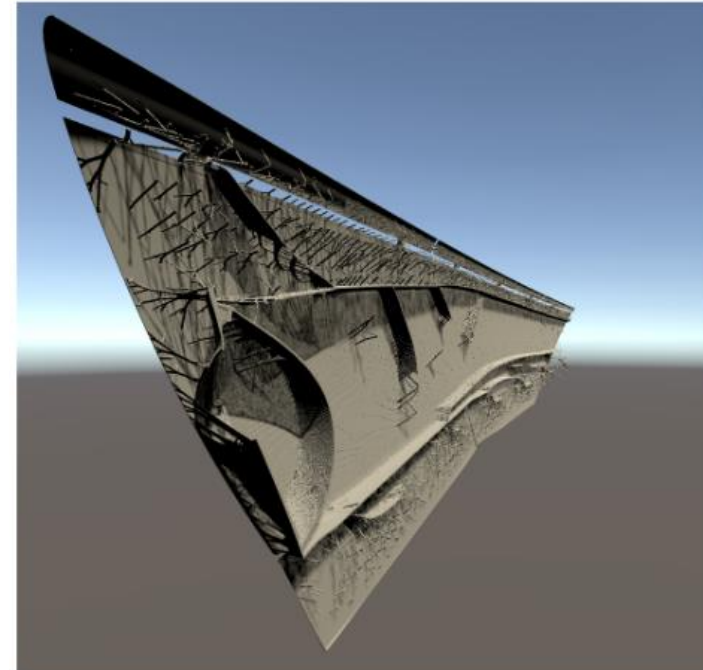
- More intuitive navigation
- Easier mapping from Real world to virtual world
- Zooming by moving head
- Requires more than 80 FPS for a pleasant experience(12.5ms pr frame)*

*WAGNER, JORGE, STUERZLINGER, WOLFGANG, and NEDEL, LUCIANA. "The effect of exploration mode and frame of reference in immersive analytics". IEEE Transactions on Visualization and Computer Graphics(2021). To appear. DOI:10.1109/TVCG.2021.30606661, 4.

Using Virtual Reality for Visualization

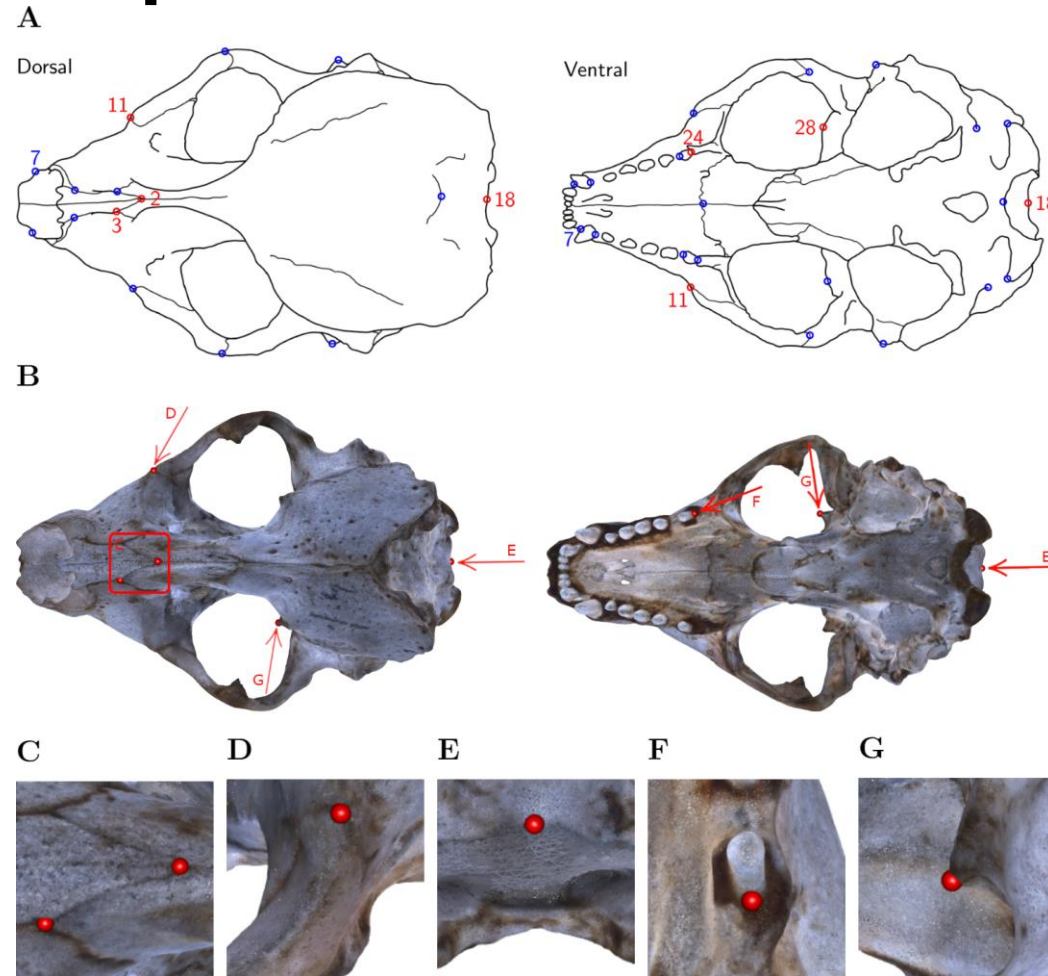


3D Scanning
14,504,882 triangles



Shape Generation
38,629,758 triangles

VR vs Desktop: Landmark Annotation



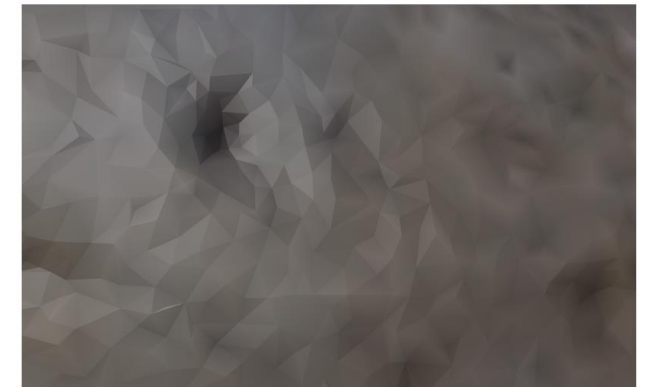
Limitation of the Study, VR and the Typical Workflow

- Based on game development
- Many smaller meshes vs one big mesh
- Game engines did not introduce 32-bit index buffers until 2017

A



B



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Compared Platforms



- Out of the box
- Custom shader
- Deferred rendering
- Allow mesh optimization
- Removed lighting effects
- Custom shader
- Forward rendering
- Out of the box
- VR plug-in

- Vulkan
- Vertex Shading pipeline
- Forward rendering
- Vulkan
- Mesh Shading pipeline
- Forward rendering

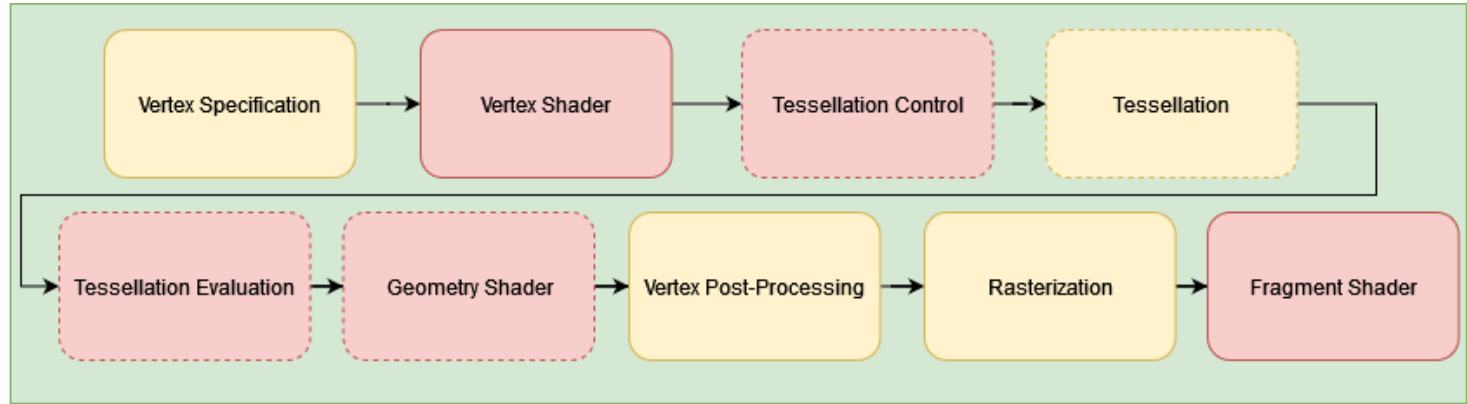
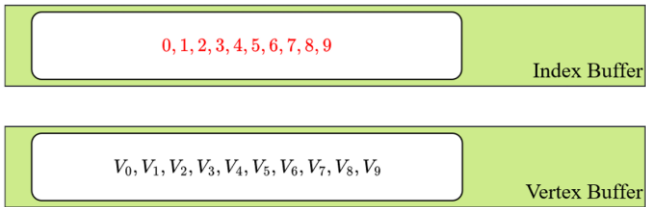
<https://unity.com/>

<https://www.paraview.org/>

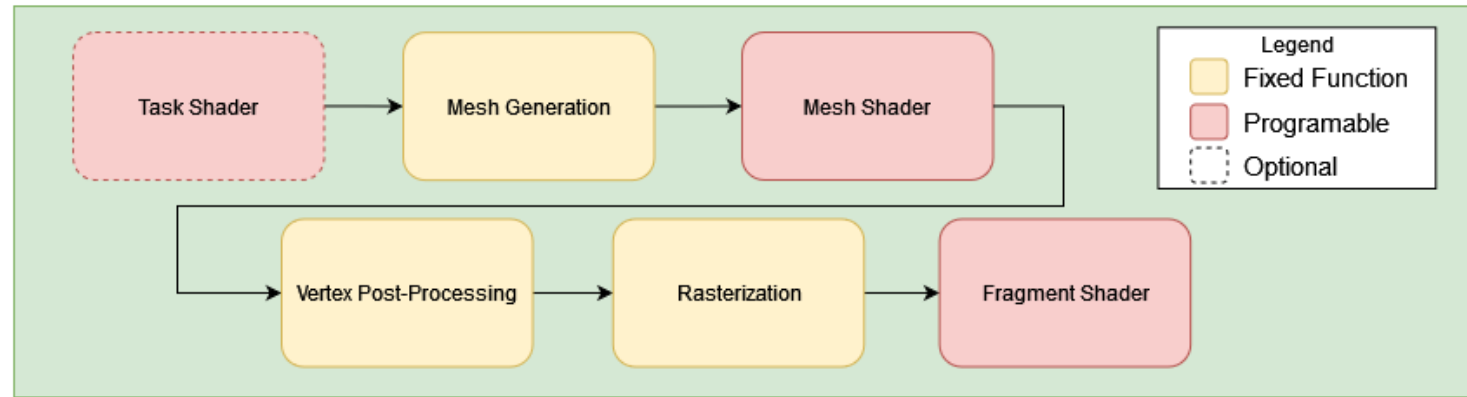
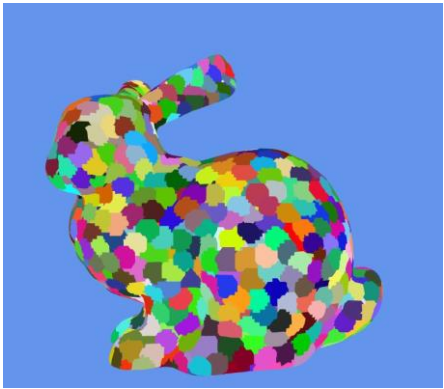
<https://www.housebeautiful.com/lifestyle/g3972/beautiful-train-routes/>

<https://www.wired.co.uk/article/japan-bullet-train-alfa-x-nose>

Rasterization Pipelines

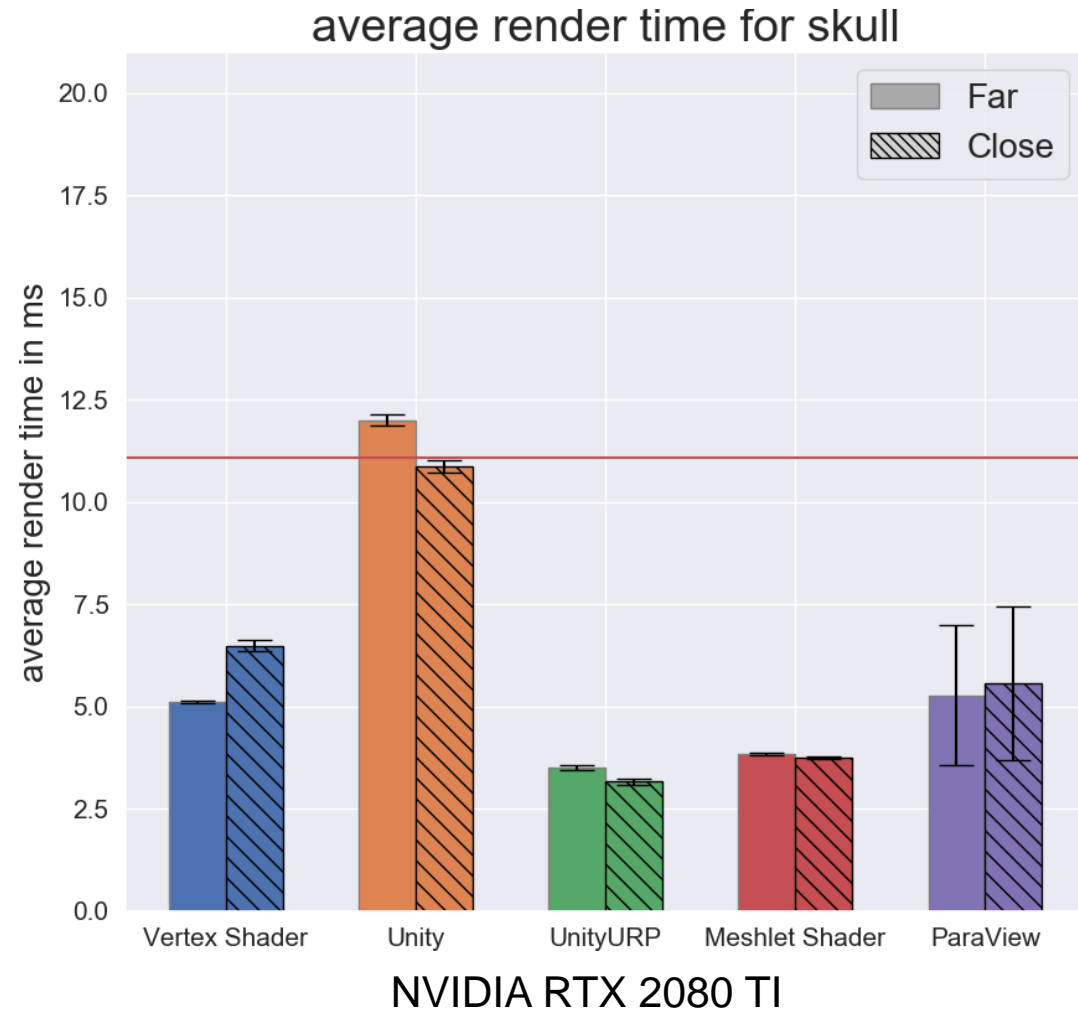


Vertex Shading Pipeline

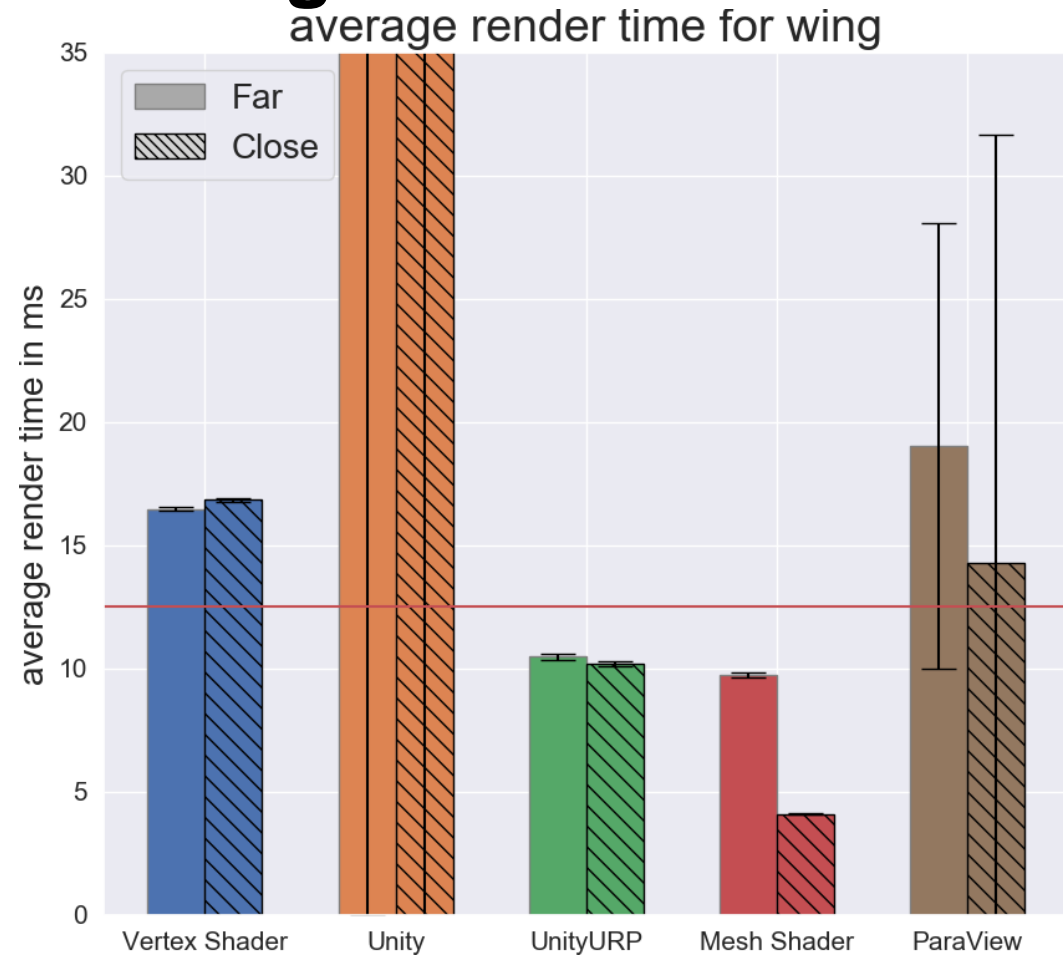
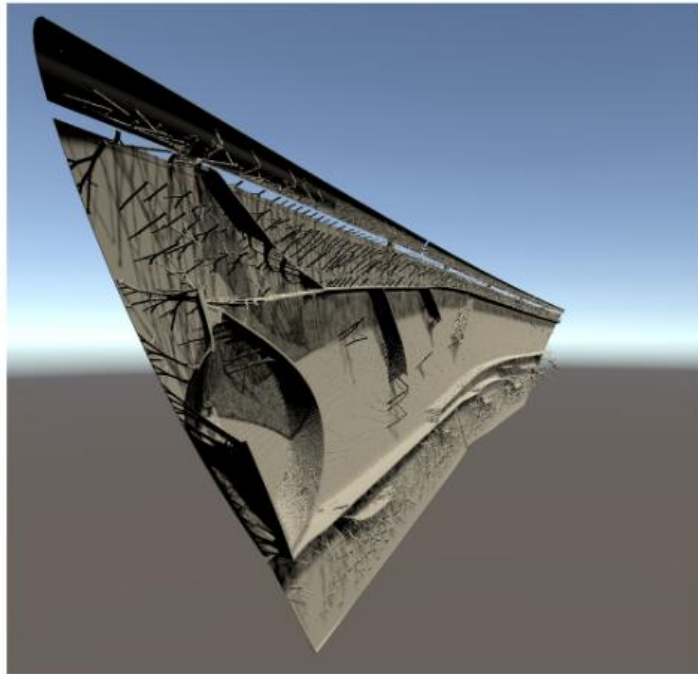


Mesh Shading Pipeline

Initial Comparison for the skull

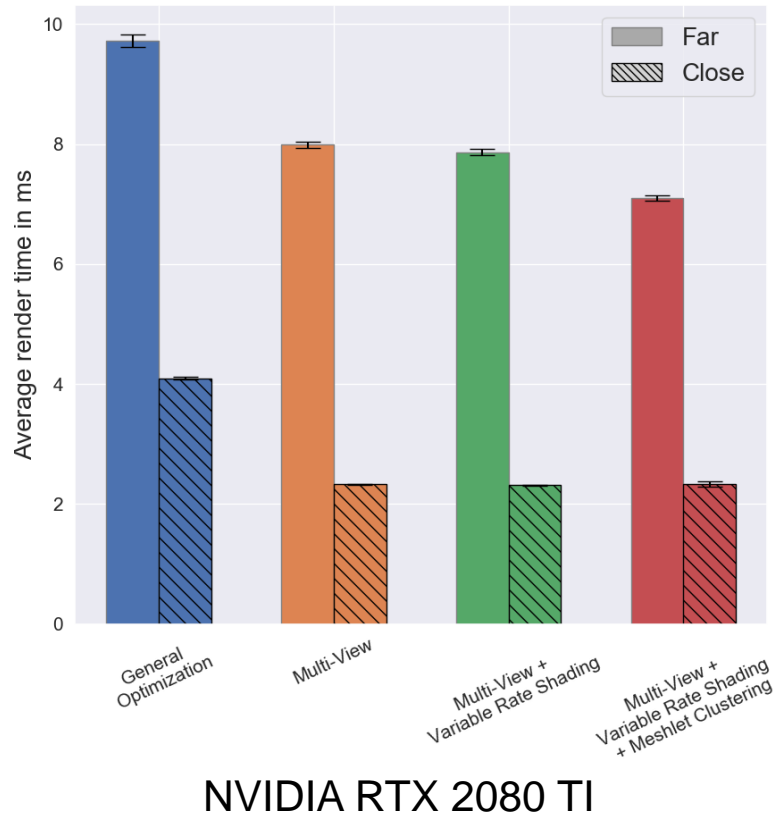


Initial Comparison for the wing



NVIDIA RTX 2080 TI

Achieving better performance with Vulkan features



- Multi-View Rendering
- Variable-Rate Shading
- Custom Meshlet Clustering Algorithm

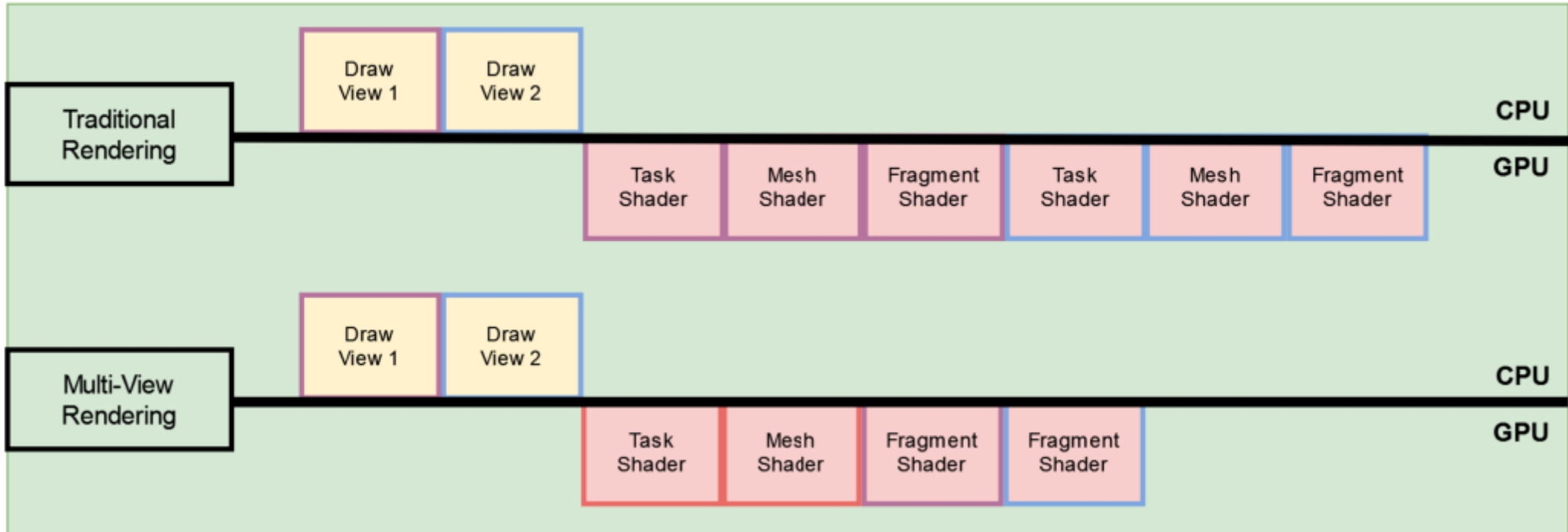
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Multi-View Extension



Multi-View Extension

- **Renderpass Creation**
 - Extend the RenderPassCreateInfo structure with:
 - renderPassMultiViewRCCreateInfo structure
 - Allows the user to set a viewmask and correlation mask
- **Create Framebuffer image attachments with corresponding layercount to match desired number of views**

- Fast Multi-View Rendering for Real-Time Applications Guggenberger and Kerbl et al.

Multi-View Extension

- **GLSL extension**

- `#extension GL_NVX_multiview_per_view_attributes: enable`

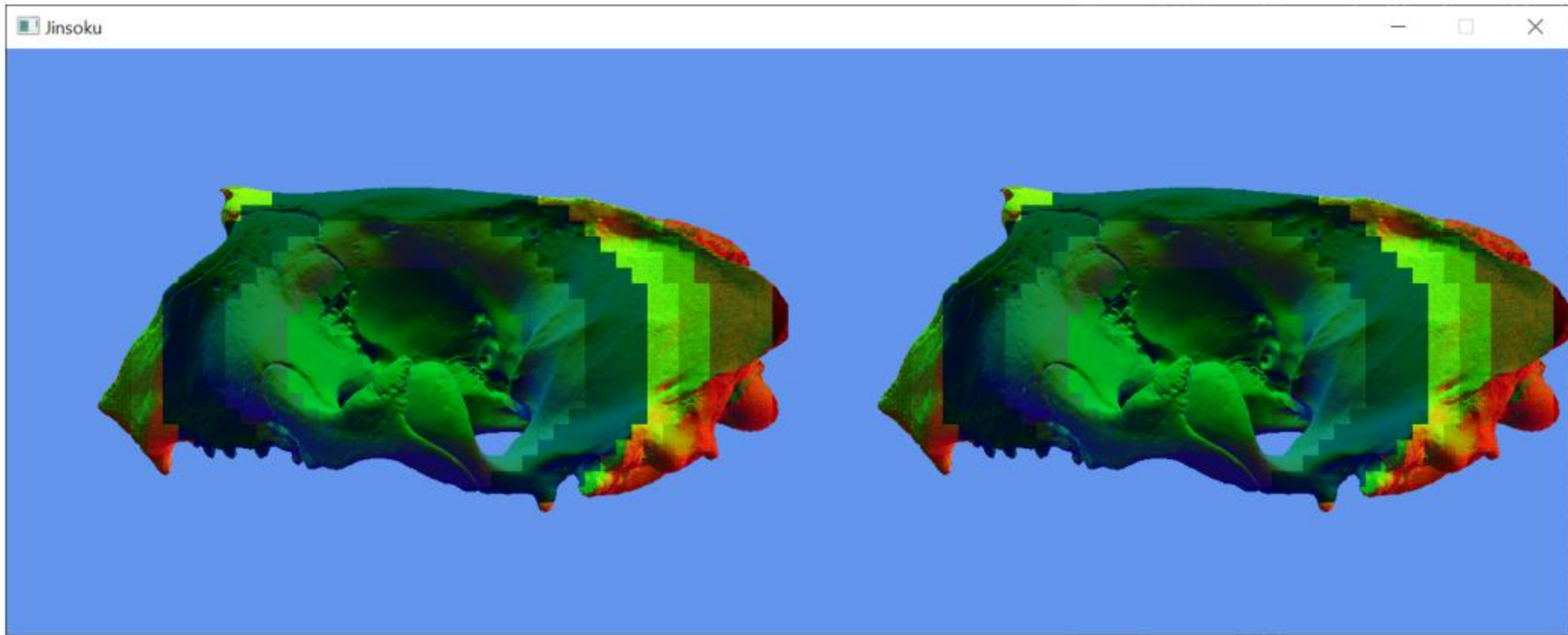
- **In Task Shader Built-in variables:**

- `gl_MeshViewCountNV`

- **Mesh Shader Built-in variables:**

- `gl_MeshViewCountNV`
- `gl_MeshViewIndicesNV[]`
- `gl_MeshVerticesNV[]`
 - `perviewNV vec4 gl_PositionPerViewNV[];`
- `perviewNV`

Variable-Rate Shading Extension



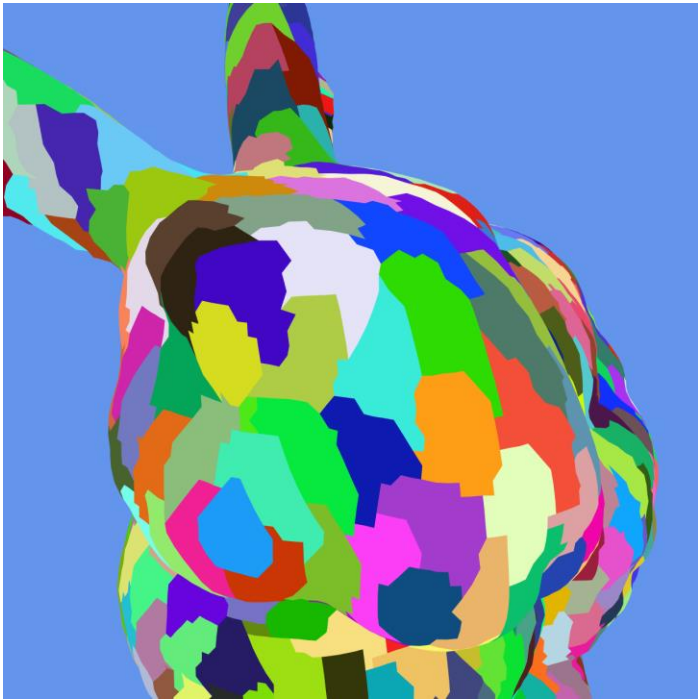
Variable-Rate Image Extension

- **Image Usage**
 - VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV
- **Allocate Image sized array**
 - Fill with values from VkShadingRatePaletteEntryNV
 - VK_SHADING_RATE_PALETTE_ENTRY_16_INVOCATIONS_PER_PIXEL_NV
 - VK_SHADING_RATE_PALETTE_ENTRY_4_INVOCATION_PER_PIXELS_NV
 - VK_SHADING_RATE_PALETTE_ENTRY_1_INVOCATION_PER_PIXELS_NV
 - VK_SHADING_RATE_PALETTE_ENTRY_1_INVOCATION_PER_2X1_PIXELS_NV
 - VK_SHADING_RATE_PALETTE_ENTRY_1_INVOCATION_PER_2X2_PIXELS_NV
- **Upload**
 - to shading image with vkCmdCopyBufferToImage();

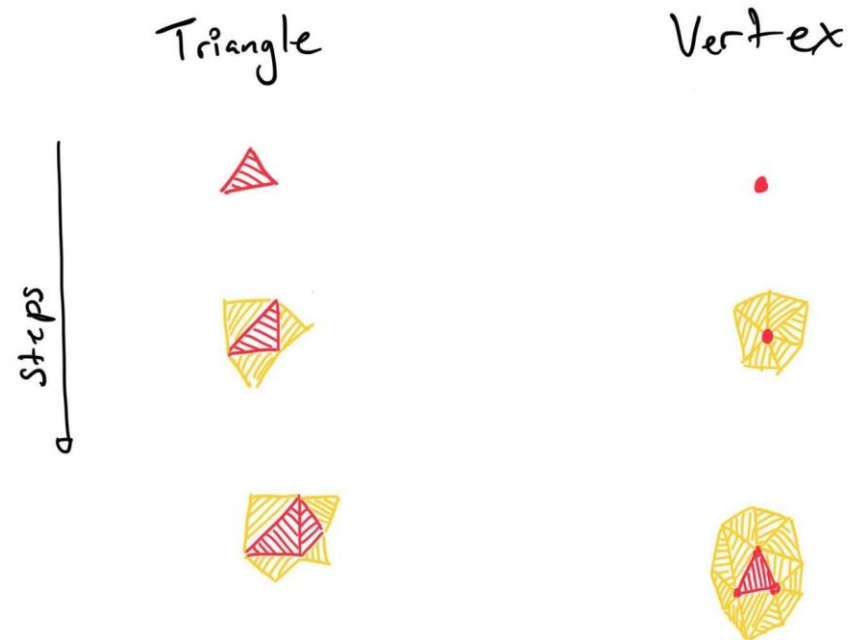
Variable-Rate Image Extension

- **Pipeline Creation**
 - Extend viewportCreateInfo structure with ShadingRateCreateInfo structure
 - Use the shadingRatePalette structure to inform about which palette entries and how many have been used for the image
- **Command buffer recording**
 - Use `vkCmdBindShadingRateImageNV()`; to bind the shading rate image before drawing

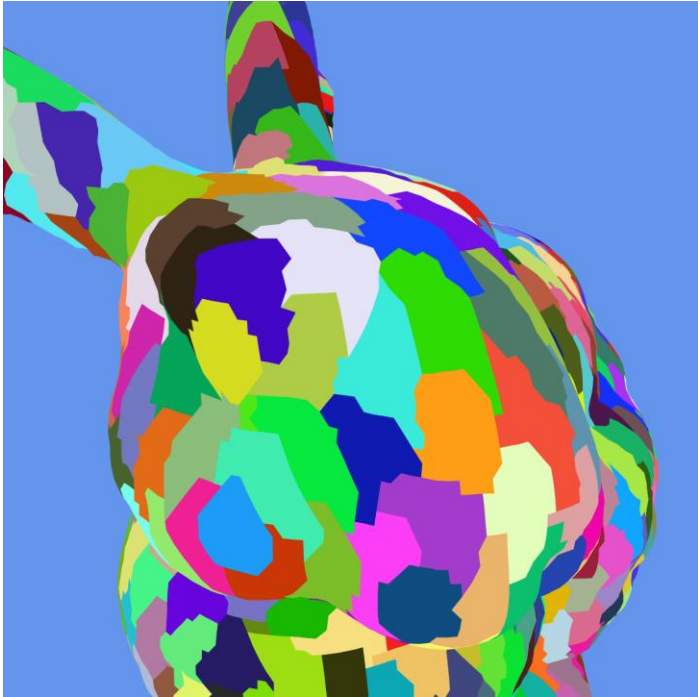
Our Meshlet Clustering Algorithm



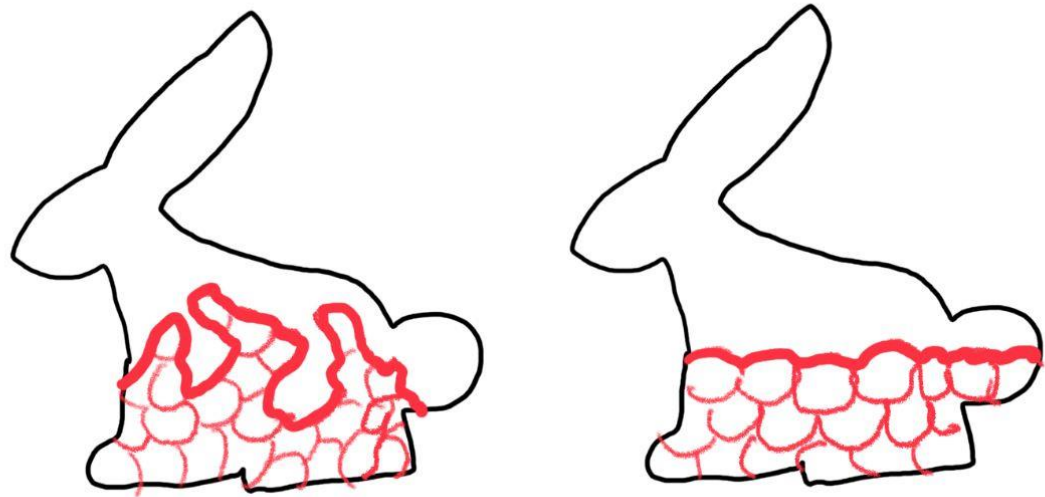
- Requires the use of a vertex data structure and triangle data structure.



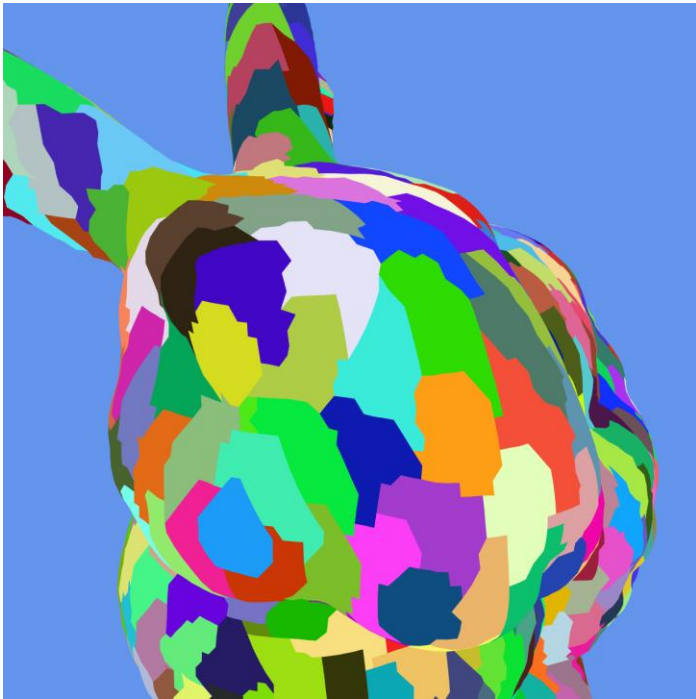
Our Meshlet Clustering Algorithm



- Sorts vertices after biggest bounding box axis length

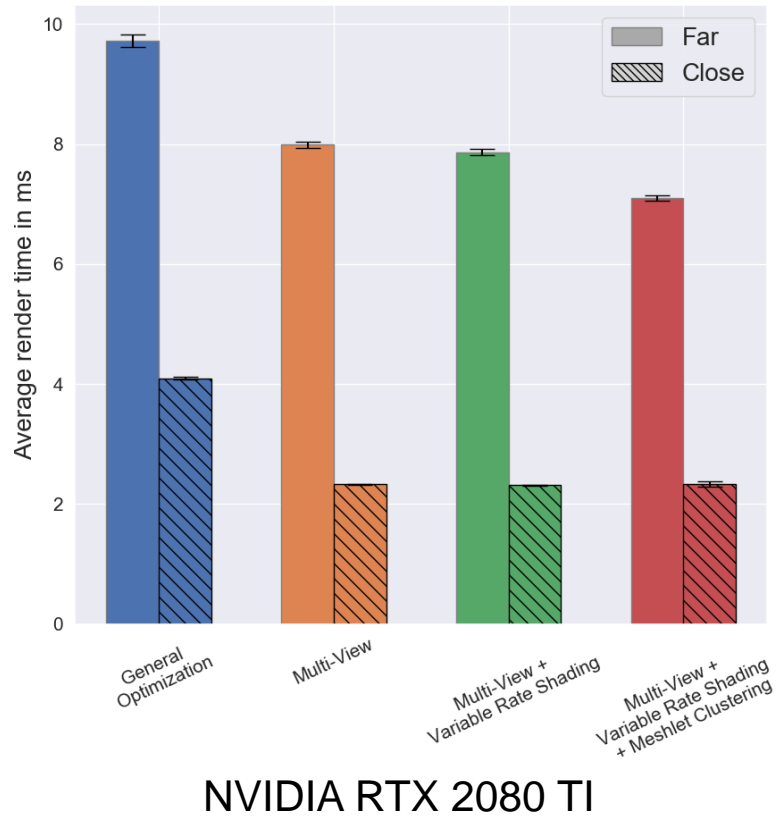


Our Meshlet Clustering Algorithm



- Run through sorted vertex list:
 - Starts meshlets from a vertex and grows it out.
 - While meshlet is not full
 - Add triangle from border that minimizes the meshlet bounding sphere or already has all its vertices in the meshlet
 - If meshlet hits vertex limit triangles at the edge are checked

Achieving better performance with Vulkan



- Access to hardware specific extensions

- `VK_NV_SHADING_RATE_IMAGE_EXTENSION_NAME`
- `VK_NV_MESH_SHADER_EXTENSION_NAME`
- Now in Vulkan Core
- Mesh Shading is in UE5 after 4 years

Thank you