THE UNIVERSITY OF ZAMBIA

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Question 2: Accelerate Ray Tracing

Graphics acceleration and performance is a very important topic in graphics application.

Please discuss two ways to accelerate ray tracing, and their pros and cons if any.

**Bounding Volume Hierarchies (BVH)**

*Bounding Volume Hierarchies (BVH)* are tree structures that organize geometric objects in a scene. By enclosing objects in bounding volumes (like spheres or boxes), the ray tracer can quickly eliminate large portions of the scene that do not intersect with the ray, reducing the number of intersection tests.

**Pros:**

* Performance Improvement: BVH significantly speeds up the ray-object intersection tests, especially in scenes with a large number of objects.
* Adaptive Refinement: BVHs can be optimized for different distributions of objects and can be updated dynamically as the scene changes.
* Good for Static Scenes: For scenes that do not change frequently, BVHs can be precomputed and reused, enhancing performance.

**Cons:**

* Build Time: Constructing the BVH can be time-consuming, particularly for complex scenes, though this is often offset by faster rendering times.
* Memory Overhead: BVH structures require additional memory, which might be a concern in memory-constrained environments.
* Dynamic Scenes: For scenes with frequently changing objects, maintaining and updating the BVH can be challenging and may negate performance gains.

**Parallel Processing (GPU Acceleration)**

Ray tracing can be accelerated by leveraging parallel processing capabilities of modern GPUs (Graphics Processing Units). This involves distributing ray tracing tasks across multiple cores of the GPU, allowing for simultaneous processing of multiple rays.

**Pros:**

* High Throughput: GPUs are designed for parallelism, allowing them to handle thousands of rays simultaneously, significantly speeding up rendering times.
* Real-Time Rendering: Techniques like real-time ray tracing (e.g., NVIDIA RTX) enable more interactive applications, making ray tracing feasible for games and simulations.
* Shader Flexibility: Using shaders, developers can customize ray tracing algorithms to optimize for specific scene characteristics

**Cons:**

* Complexity: Implementing ray tracing on a GPU can be more complex than traditional CPU-based approaches, requiring knowledge of parallel programming and GPU architecture.
* Hardware Dependency: Performance gains are highly dependent on the hardware; older GPUs may not support the latest ray tracing features.
* Power Consumption: High-performance GPUs can consume significant power, which may be a drawback in portable devices or low-power applications.