A Technical Examination Into Total War Three Kingdoms

Exploring Ray Tracing Possibilities for Lighting and Reflections

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1. **Purpose**
   The report examines how Total War: Three Kingdoms implements lighting and global illumination, evaluates whether ray tracing could be integrated into the game's rendering pipeline, and outlines the expected performance impact and QA considerations, including potential defects and test strategies.
2. **Scope**
   The scope of this analysis is limited by the following constraints:
   - No access to Creative Assembly's internal documentation or developers; all information about the rendering pipeline is inferred from graphics knowledge and frame captures.
   - Observations are based solely on the production release build of Total War: Three Kingdoms.
   - No modification of the game's engine or source code is performed; ray-tracing feasibility is evaluated theoretically, not implemented.
3. **Tools and Environment**
   Tools and environment used:
   - Total War: Three Kingdoms, Version 1.7.1
   - RenderDoc, Version 1.40
   - Operating System: Windows 11 Home
   - DirectX Runtime: DirectX 12
   - NVIDIA Studio Driver 576.52
   - CPU: Intel Core i7-11800H @ 2.30 GHz
   - GPU: NVIDIA GeForce RTX 3060 Laptop GPU
   - Direct3D Feature Level: 12_1
4. **Methodology**
   The inspection process was performed using RenderDoc to capture and analyse individual frames. Each render pass related to lighting, global illumination, and shadows was examined. For Total War: Three Kingdoms, this included the ambient lighting pass used for global illumination, the diffuse shadow pass, and G-buffer textures. Certain passes could not be fully interpreted due to engine-specific implementations, but the available data provided sufficient insight into the rendering pipeline.
5. **Findings**
   Key findings:
   - Global illumination appears to rely on a precomputed or constant ambient color rather than dynamic GI techniques.(A2)

- Diffuse shadows are generated using a 2D texture populated through ray-casting methods rather than hardware-accelerated ray tracing. (A3)
- Hardware-accelerated ray tracing would introduce significant performance cost relative to the game's frame budget.
- The current frame budget is insufficient to support full ray-traced global illumination. (A5)
- Limited ray-traced features may be viable for future titles as GPU capabilities improve.
- Some existing passes already use software-based ray-casting, indicating potential migration paths to hardware-accelerated ray tracing for select effects.

6. **Analysis**

   For real-time battles, the performance cost of ray-traced global illumination exceeds the available GPU budget, making full GI ray tracing infeasible. However, ray-traced shadows may be achievable because the current shadowing system already uses ray-casting, and hardware acceleration via RTX cores could reduce cost.

   For the campaign map, CPU-bound gameplay and the priority on readability and information delivery mean that ray tracing offers minimal benefit. Screen-space reflections and simple global illumination techniques are more efficient and appropriate.

   For the main menu, ray tracing provides no functional improvement because lighting and shadows are minimal and the primary requirement is interface clarity.

7. **Conclusion**

   Ray tracing support in Total War: Three Kingdoms is partially viable. Ray-traced shadows could be integrated into real-time battles, but ray-traced global illumination is not feasible within the current performance constraints. For QA, automated performance testing would be required, with a success threshold of maintaining 60 FPS and failure defined as any drop below 30 FPS. These tests should be included in overnight automated test cycles.

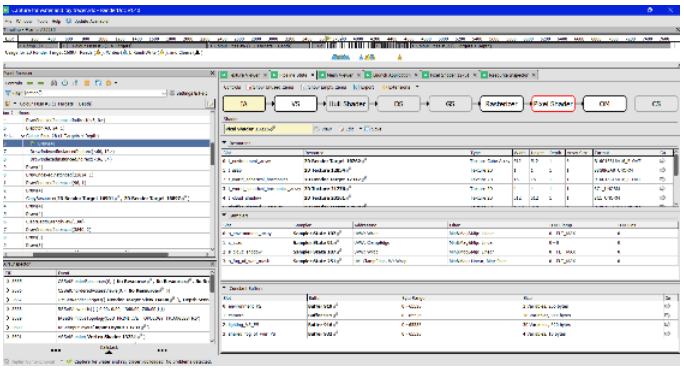
8. **Recommendations**

   - For future titles, integrate ray-traced shadows leveraging RTX hardware and AI-based denoising(A1) to keep GPU costs manageable.
   - Implement automated performance testing with clear thresholds: 60 FPS as the expected target and drops below 30 FPS flagged as failures.
   - Evaluate ray-traced global illumination experimentally in controlled test scenes, focusing initially on a single battle scenario to assess visual fidelity and performance impact.
   - For any expanded ray-tracing pipeline, validate correctness across models, terrain, skybox, lighting, shadows, water, and UI, while ensuring frame times remain within the required performance budget.

9. Appendix

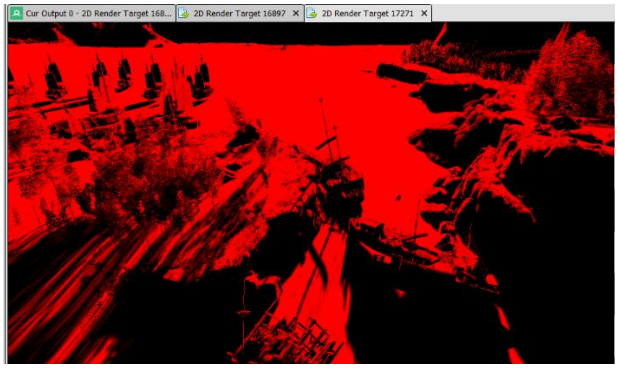
A1. Ray tracing and AI denoising technologies referenced are based on NVIDIA RTX architecture.

A2 The Pixel Shader for the Reflections. This includes GI.



A3 Diffuse shadow map

A4 Shadow Map



A5 frame time / gpu usage for real time battles

A7 where GI affects the scene edited image of final image