On-Device AR/VR 3D Reconstruction and Rendering

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Motivation

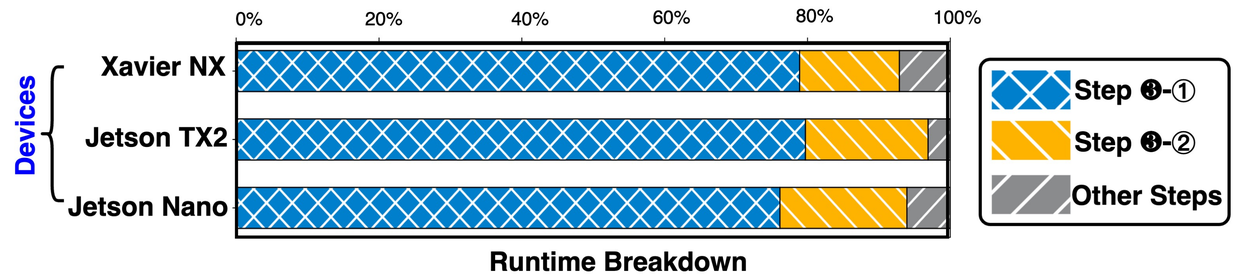
- **Motivation:** on-device 3D reconstruction and rendering in **highly desirable in AR/VR**

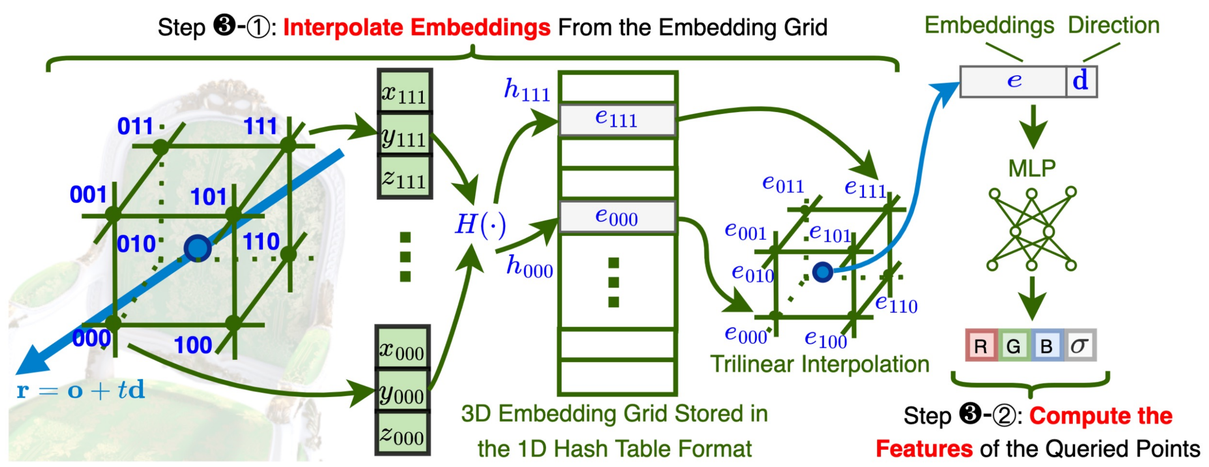
Virtual Meetings | Metaverse | Autonomous Driving Simulation

- **Challenge:** **Instant** (< 5 seconds) NeRF-based reconstruction (SOTA method) and **real-time** (> 30 FPS) rendering is **still not possible**
- **Our work:** an **algorithm-hardware co-design** framework to enable instant 3D reconstruction
  - ✓ **1.6 sec.** per scene within 1.9W
  - ✓ **> 30 FPS** rendering on a laptop

Analyze the Efficiency Bottleneck

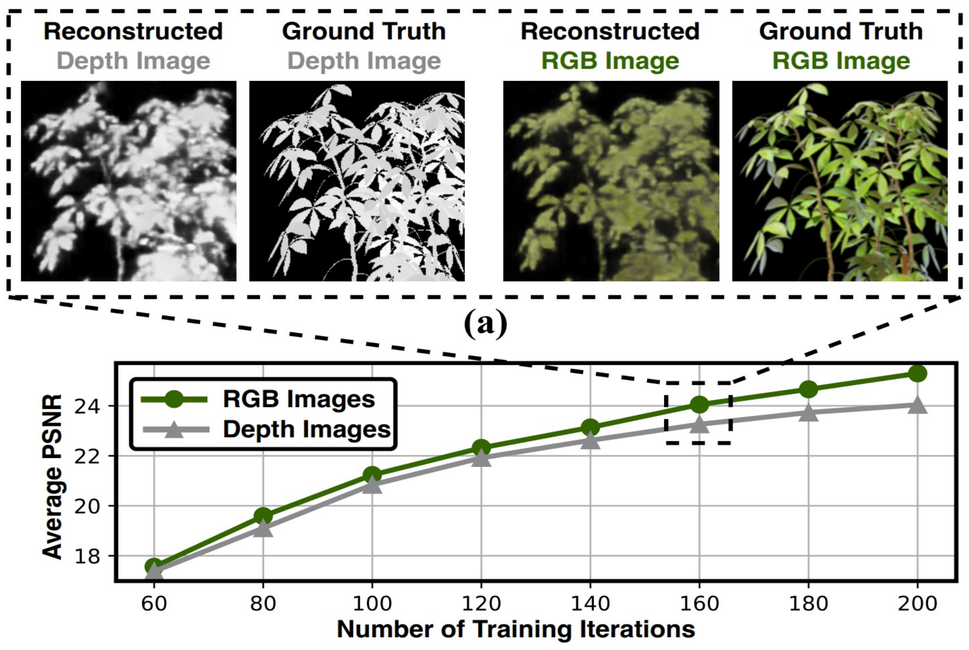
- **Bottleneck:** **Interpolating NeRF embeddings from a 3D embedding grid** (> 200,000 times per iteration)





Proposed Algorithm

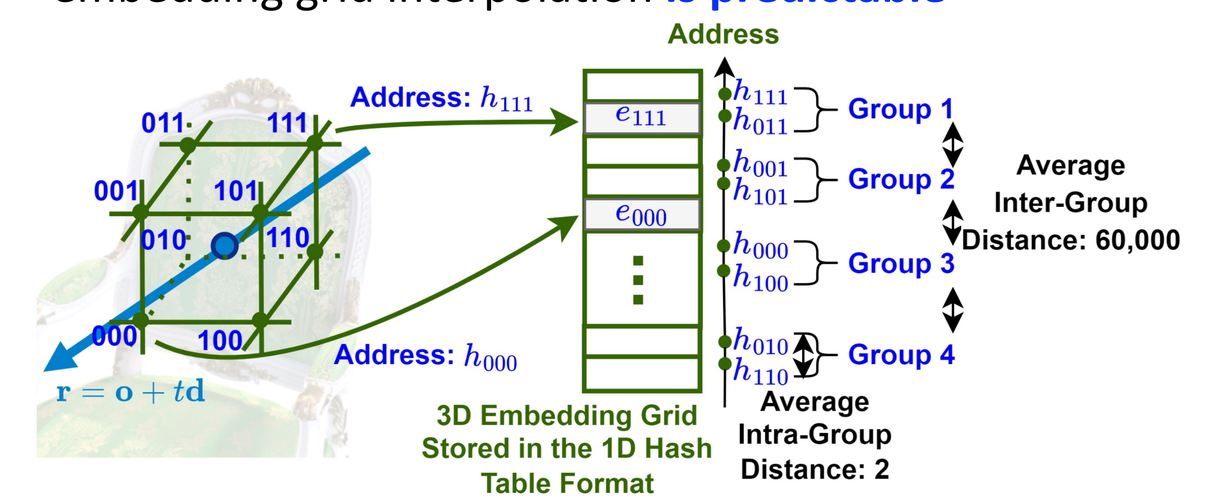
- **Observation:** **color** and **density** have different impacts



- **Proposed algorithm:** **different model complexities** for the **decomposed branches** of color and density

Proposed Accelerator

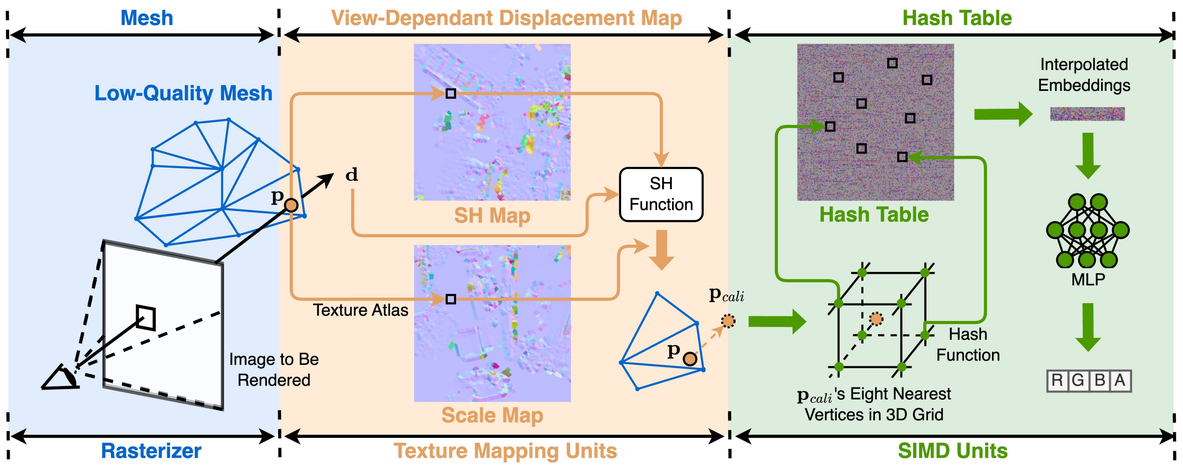
- **Observation:** the **memory access pattern** during embedding grid interpolation **is predictable**



- **Proposed accelerator:** **reorganize memory accesses** to reduce data movement
  - ✓ Feed-forward **Read Mapper**
  - ✓ Back-propagation **Update Merger**

Proposed Real-Time Rendering Pipeline

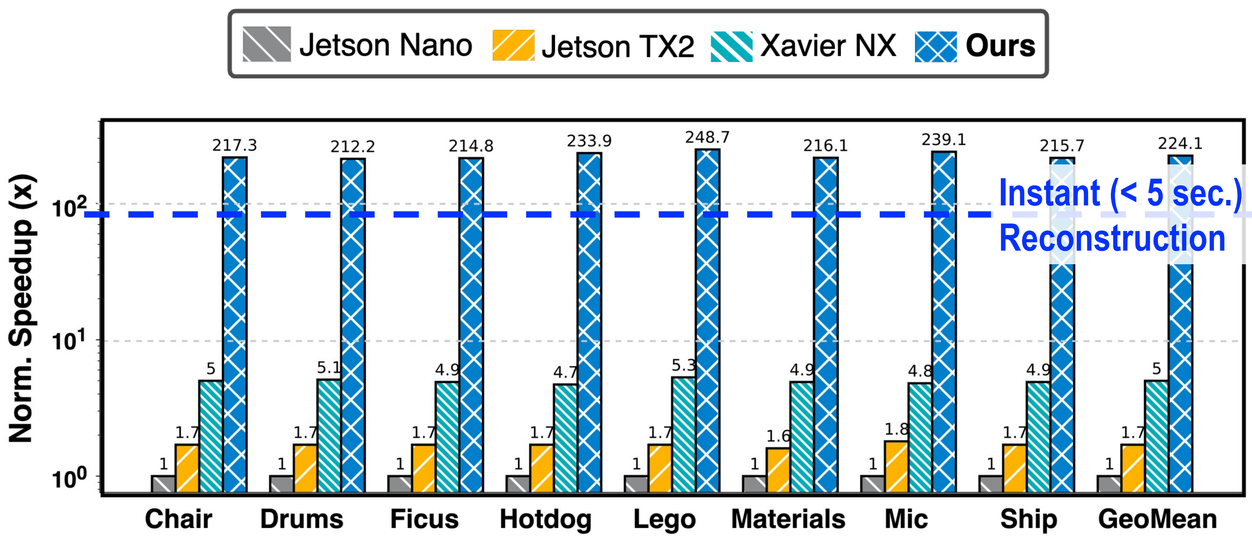
- **Proposed rendering pipeline:** integrate a **low-quality mesh**, a displacement **map**, and an embedding **grid**



- ✓ Real-Time Rendering
- ✓ Small Storage size
- ✓ Photorealistic Quality

Interactive Demo

Ours vs. Baselines



Our framework has delivered **the first instant on-device NeRF-based 3D reconstruction**

The corresponding works have been published in ISCA 2023 and 3DV 2024