Server-Based Rendering of Large 3D Scenes for Mobile Devices Using G-Buffer Cube Maps
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Motivation and Goals

Delivery of **high-quality 3D visualizations** of complex, massive 3D content in a way that allows for **interactive exploration** of a 3D geovirtual environment with only **moderate hardware requirements**.

3D visualization and massive **3D models on mobile devices**

Lower entry-barriers for users through **intuitive, touch-based interfaces** for complex 3D content (especially on mobile devices)

Complex 3D scene

Interactive, lightweight client application
Streaming Approaches for 3D Models

Common distributed visualization systems transfer geometry, textures and scene graphs to client applications.

Large 3D scenes are difficult to implement and operate on mobile devices due to

- Limited network bandwidth / reliability
- Limited main memory
- Limited processing power
- Limited 3D rendering hardware and software capabilities
Image-Based Approach: G-Buffer Cube Maps

Server-side generation of **G-buffer cube maps** and transfer to 3D clients

- **3D scene approximation**
  - Discretized
  - Omni-directional
  - Viewpoint-dependent
  - Multi-layered (color, object id, depth, normals, ...)

![Diagram of 3D Server and Interactive 3D Client](image.png)
Image-Based Approach: Characteristics

- The complexity of G-buffer cube maps is independent from the 3D scene’s complexity.
- 3D rendering within a **controlled server environment**
  - Known and tested server-side 3D graphics hardware and software
  - Stable implementation of advanced 3D rendering techniques (e.g., multi-pass rendering, shader programming)
  - Independent from client capabilities
- 3D Server interface is based on the Web View Service (WVS)
  - Standard proposal for 3D portrayal of the Open Geospatial Consortium (OGC)
  - Reusable, interoperable 3D visualization
- Original **3D content is kept protected**: 3D scene data never leaves the server environment.

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3D Client

Interactive display of and user interaction with a reconstructed 3D scene from server generated G-buffer cube maps

1. Cube map panorama (12 textured triangles)
   - High quality, omni-directional visual representation of large server-side 3D scene
   - Only valid for one viewpoint

2. Geometry reconstruction from depth information
   - Approximated representation during camera transitions
   - Allows a user to navigate uninterrupted through the 3D scene
System Overview

3D Request Process
- Cube-Map Requests
- Cube-Map Request Manager

3D Rendering Process
- 3D Scene Data
- Core 3D Rendering Process
- Intermediate G-buffer Cube Maps
- Stylization/Finishing Process

Streaming Process
- G-buffer Cube Maps
- Cube-Map Streaming Manager

3D Client
- 3D Interaction Management
- Session Management
- Request Pool
- Local Graphics Data
- Reconstructed Scene Rendering

Network

Streaming Process
- 3D Scene Reconstruction
- G-buffer Cube Maps Cache

Core 3D Rendering Process

Stylization/Finishing Process

Intermediate G-buffer Cube Maps

Cube Maps

Cube-Map Request Manager

Request Pool

Local Graphics Data

Reconstructed Scene Rendering
Case Study – Berlin 3D

- **Virtual 3D city model of Berlin:**
  - One of the world’s largest fully textured 3D city models
    - >550,000 Buildings,
    - >4,000,000 facade textures,
    - >350 high detail buildings
  - 3D city model as platform for data integration and presentation

- **Use case: City marketing**
  - Expensive transport of rendering and storage systems for city model presentation on real estate fairs
  - 3D City model as iPad App for mobile presentation
  - Significantly lower costs through portable solution

- **Result:** Users realize the application as “true 3D application”
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Conclusions and Future Work

- **Server-generated G-buffer cube maps**
  - Decouple server-side 3D scene complexity from transmitted data and significantly reduce complexity on client side
  - Facilitate interactive, high-quality visualization of large 3D scenes on mobile devices

- Server side rendering **facilitates development and distribution of high-end rendering techniques** since no end-user hardware/software need to be touched

- Users tend **to accept network delays** as well as small amounts of visual artifacts **as long as their interaction does not “get stuck”**

- **Simplicity and moderate hardware requirements** of client application makes plugin-free, browser-based **WebGL implementations** feasible
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