VU Entwurf und Programmierung einer Rendering-Engine

Organization

186.166 - WS 2.0

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Organization

- **Vorlesung**
  - Monday, 16:15 (s.t.) - 17:45
  - Seminarraum 186, Institut für Computer Graphik und Algorithmen
  - ECTS efforts: approx half/half

- **Übung**
  - As a project, implement a module for a rendering engine
  - Topics can be chosen by students
  - There will be an extra “Vorbesprechung” for the exercise: 6.11.2017
    - Including ideas and a discussion of possible topics
Student project

- Will have extra lecture which describes tasks more precisely (6.11.2017)
- Similar to previous years:
  - Rendering and optimization a scene. This includes:
    - Geometry processing (e.g. Terrain generation, Meshes,...) or model loading
    - Acceleration data structure or optimization algorithm
    - Rendering of the scene
Exam

- Hand in (per email) the project + a written report
  - Till 2 days before the exam date
  - Written report (2-4 pages)
    - Description of the project
    - Description of the used techniques
    - Analysis of the performance

- Oral exam
  - End of January till end of March
    - Email with 2 possible dates to hs@vrvis.at
  - Demo of the project
  - Two questions of the lecture content
    - Details not that important, but understanding of the topics.
Contact

Harald Steinlechner

- VRVis Research Center, Donau-City-Straße 11
- hs@vrvis.at
- To register informally, send me an email including your name and matrikelnummer.

VO Homepage

- https://www.cg.tuwien.ac.at/courses/RendEng/
The mission of a rendering engine….

- Provide easy to use software components...
- which can be used to solve rendering engine tasks (like a toolbox)

In order to accomplish this, we need:

- Algorithms and Datastructures
- Graphics API & Hardware Insights
- API design
- Domain specific languages (e.g. scene description)
Content of this LV

- Requirements for the design of rendering engines
- Hardware and Graphics APIs (OpenGL, Direct3D, Vulkan,..)
- Scene Representation (Scene graphs, display lists, command buffers,...)
- Static and Dynamic Data (Incremental Update Techniques)
- Optimizations (Caching, Culling, Level of Detail, Bounding Volume Hierarchies, Just-In-Time Optimization)
- Resource Management
- Domain Specific Languages (HLSL, Spark, FShade, Semantic Scene Graph,..)
- Reusable Components/Design for Rendering Engines
About the LV team & Aardvark

- LV Team is basically the aardvark core development team.
- Active development of the aardvark rendering engine since 2006 with Robert F. Tobler.
- Roberts mission: easy to use but high-performance rendering engine.
- Aardvark - An Advanced Rapid Development Visualization and Rendering Kernel
  - Heavily used in research + industry projects
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Language/Approach</th>
<th>Description</th>
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<tbody>
<tr>
<td>Till approx 2002</td>
<td>Aart (Obj C)</td>
<td>Approx. 2002</td>
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<td>Ave (C++)</td>
<td>Approx. 2005</td>
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<td>Traditional Scene Graph</td>
<td>Approx. 2008</td>
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<td>Aardvark (C#)</td>
<td>Semantic Scene Graph [Tobler 2011]</td>
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<td>Aardvark 2010</td>
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<td>Performance!</td>
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<td></td>
<td>Lazy Incremental Computation</td>
<td>Aardvark 2015</td>
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<td>For efficient Scene Graph Rendering [Wörister et al. 2013]</td>
<td>Composable Shaders [Haaser et al. 2014]</td>
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<td>Towards Incremental Computation, Attribute Grammars for Incremental Scene Graph Rendering</td>
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<td>Approx 2016</td>
<td>aardvark.rendering</td>
<td>Fast and flexible!</td>
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<td>aardvark.base</td>
<td>Usability, Remote Rendering, Aardvark in the browser</td>
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<td>2017</td>
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<td></td>
<td>General purpose incremental Computation, Incremental Rendering VM [Haaser 2015]</td>
<td>Vulkan, ELM architecture, Aardvark goes web</td>
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Challenges

- **Size of data-sets**
  - Often requires out of core approaches

- **Dynamic and static geometry**

- **Efficient graphics hardware utilization**

- **Support for special effects**
  - APIs for accessing special hardware features
  - Provide mechanisms to specify for example shaders and post processing

- **Many different application areas: Focus on real-time applications**
  - Terrain, laserscan, reconstructed data, game levels
  - Architecture and planning
  - Light simulation (Global Illumination)
  - Games
  - Interactive Editing applications
Questions

How to structure a rendering engine

- What interfaces and modules useful
- How to transfer data
- How to manage memory (we have GPU and main memory)
- How to store data in memory (e.g. for efficiency reasons)
- How to optimize, how to make use of multiple CPU cores

Graphics hardware specific questions

- What to compute in shaders
- What to compute on CPU (in what precision?)
Topics I

- Tools/Algorithms/Concepts to implement rendering engines
- Hardware/Graphics API insights
- How to structure rendering engine into modules
  - (Low cost) abstraction techniques
  - Compiler techniques
- Important data-structures in practise
  - k-d-Trees, BSP trees, Octrees
- Performance considerations
  - Optimizations (how to pack buffers etc)
  - Costs of programming language abstractions (e.g. can we afford virtual function calls?)
- How to manage large scenes (performance + memory)
- Approaches for implementing lighting/material systems
Topics II

- Dependencies and incremental computation for rendering engines
  - Efficient ways to handle dynamic data
- Scene representation
- Rendering of big scenes
  - Terrain-rendering, rendering precision, caches
- Parallelization for rendering engines

- Not content of this LV:
  - Graphics programming tutorial
  - How to use existing engines
  - How to implement concrete tooling (e.g. level editor, material editor)
Approach of the lecture

- Motivation and types of rendering engines
- Scene representation
- Graphics Hardware and Insights
- Algorithms and methods for speeding up rendering
- Acceleration data structures for rendering engines
- Scene Description/Shader Languages
- Real-World implementations of material/lighting system
  - Including lightmap packing, instant radiosity, deferred rendering techniques,...
Questions