Chapter 5 - The Scene Graph

• Why a scene graph?
• What is stored in the scene graph?
  – objects
  – appearance
  – camera
  – lights
• Rendering with a scene graph
• Practical example
The 3D Rendering Pipeline (our version for this class)

1. 3D models in model coordinates
2. 3D models in world coordinates
3. 2D Polygons in camera coordinates
4. Pixels in image coordinates

- Scene graph
- Camera
- Animation, Interaction
- Rasterization
- Lights
Why a Scene Graph?

- Naive approach:
  - for each object in the scene, set its transformation by a single matrix (i.e., a tree 1 level deep and N nodes wide)
    - advantage: very fast for rendering
    - disadvantage: if several objects move, all of their transforms change

- Observation: Things in the world are made from parts

- Approach: define an object hierarchy along the part-of relation
  - transform all parts only relative to the whole group
  - transform group as a whole with another transform
  - parts can be groups again
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Geometry in the Scene Graph

- Leaf nodes are basic 3D objects.
- Non-leaf nodes (groups) contain a \textit{transformation}:
  - can have one or several children.
  - transformation is given by a homogeneous Matrix.
- Root is the entire world.
- Nodes can be the child of several groups:
  - not a tree, but a directed acyclic graph (DAG).
  - effective reuse of geometry.
Appearance in the Scene Graph

- Scene graph also contains appearances
  - Appearance: E.g. Color, reflection, transparency, texture
    Details see next lecture
  - can be reused similarly to geometry

- Appearance can be only partially specified
  - unspecified values are inherited
Lights in the Scene Graph

• Light sources also need a position and/or direction
  – Just include them into the scene graph
  – Can be animated just like geometry

• Lights can be in local coordinate systems of geometry groups
  – move with them
  – example: lights on a car
The Camera in the Scene Graph

• Camera also needs a position and direction
  – Just include it into the scene graph
  – Can be animated just like geometry

• Camera can be in local coordinate systems of geometry groups
  – move with them
  – example: driver’s view from a car
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Scene graph traversal for rendering

- set $T_{\text{act}}$ to $T_{\text{Auto}}$
- push state
- set $T_{\text{act}}$ to $T_{\text{act}} \times T_{\text{Karosserie}}$
- push state
- set $T_{\text{act}}$ to $T_{\text{act}} \times T_{\text{Chassis}}$
- render Quader1
- pop state
- set $T_{\text{act}}$ to $T_{\text{act}} \times T_{\text{Kabine}}$
- render Quader2
- pop state
- pop state
- set $T_{\text{act}}$ to $T_{\text{act}} \times T_{\text{Räder}}$
- ...
Scene Graph Libraries

- Scene graphs exist on a more abstract layer than OpenGL!

- VRML/X3D
  - descriptive text format, ISO standard

- OpenInventor
  - based on C++ and OpenGL
  - originally Silicon Graphics, 1988
  - now supported by VSG3d.com

- Java3D
  - provides 3D data structures in Java
  - not supported anymore

- Open Scene Graph (OSG)

- Various Game Engines
  - e.g. JMonkey 3 (scene graph based game engine for Java)

Scene Graphs in Practice

• Creation of scene graphs and objects
  – Specific authoring software (e.g. Blender, Maya, 3DS Max)

• Assets (models, objects) exported to exchange formats
  – E.g. (X3D, ) Wavefront OBJ (.obj), 3ds Max (.3ds), Ogre XML (.mesh)

• Objects typically are tesselated
  – Polygon meshes
  – No primitive geometric objects visible/readable anymore

• Example:
  – JME Scene Viewer / Composer
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Example of a scene graph

- Graph to be drawn together in the lecture
- VRML world linked from the class page