Foundations of 3D Scene Modeling

Recap

Cornerstones of image generation:

- **3D scene**
- Rendering algorithm
- Raster image

<IMAGE: high-level overview of three main components>

Where we are today

<IMAGE: tree-like structured knowledge of the course>

Introduction

Elements of any 3D scene:

- 3D model(s)
- Light source(s)
- Camera(s)

<IMAGE: high-level overview of three main components>

Complex example

<IMAGE: An motivation image that we will understand by the end of the lecture.>

Foundations of 3D models

Objects around us.

Representing 3D models requires:

- Representation of **shape** - surface geometry
- Representation of **material** – surface appearance

Foundations of shape representation

Foundational shape representations are:

- Meshes
- Curved surfaces

Foundations of Meshes

- Pros:
  - Simple, a lot of effort has been made to approximate shapes with meshes
- Cons:
  - Not every object is well suited to mesh representation:
    - Shapes that have geometrical detail at every level (e.g., fractured marble)
    - Some objects have structure which is unsuitable for mesh representation, e.g., hair which has more compact representations
- Triangle mesh
- Quad mesh

Triangle mesh introduction

- Triangle mesh is foundational and most widely used data-structure for representation of a shape in graphics
- Triangle mesh consists of many triangles joined along their edges to form a surface
- Triangle is fundamental and simple primitive:
  - All vertices lie in the same plane
- Triangle mesh has nice properties:
  - Uniformity: simple operations
    - Subdivision: single triangle is replaced with several smaller triangles. Used for smoothing
    - Simplification: replacing the mesh with the simpler one which has the similar shape (topological or geometrical). Used for level of detail

<IMAGE: example how certain flat shapes are created with triangles>

Example how certain curved shapes are approximated with triangles

- Conceptual approximation: find points on complex shape and connect adjacent points with a mesh structure
  - For example: scanning and reconstruction
- Example: sphere vs icosahedron
  - Each point on icosahedron is close to point of sphere
  - Each normal vector of icosahedron is close to vector normal of the sphere in the same point. But, function that assigns normals to the sphere is continuous while for icosahedron is piecewise constant → this influences reflection of light!

Description of meshes

- Description of mesh requires:
  - List of vertices and triangles (edges are inferred from triangles)
  - Vertex table – geometry
  - Triangle (faces) table - topology

Quad mesh

- Good modeling primitive
- Complexity:
  - Easy to create a quad where not all vertices lie on a plane
- In graphics pipeline it is always transformed to triangle.
- In raytracing rendering plane-ray intersection must be defined

Foundations of Curved surfaces

Foundations of surface material

Foundations of Light sources

- Sources of Light
- Models of light:
  - Distant lights
  - Point lights

Distant lights

Point lights

Foundations of camera

How camera works

Pinhole camera model and parameters

Transformations of 3D scene elements

Translation

Rotation

Scale

Coordinate systems

Coming together

A 3D scene completed

Back to the complex example

- What have we learned

Literature

- Computer graphics: Principles and practice (J.F.Hughes)
- https://github.com/lorentzo/IntroductionToComputerGraphics/wiki/Foundations-of-3D-scene-modeling