CSC 240 Computer Graphics
Video 13: Hierarchical Models

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Some slides & content courtesy Sara Mathieson & Eitan Mendelowitz
Thought Exercise

How many items are in this scene? How would you group them?
Hierarchical Models

Hierarchical models organize a scene into parts and subparts.

- Useful for keeping track of all the pieces
- Subpart position is measured relative to parent
- Move parent ⇒ move all subparts with it
How to Group

Scene Organization:
Room
Floor
Plane
Chair
Leg
Seat
Back
Table
Bowl
Sphere
Sphere
Box
Box
Box
Alternate Tree
Coding with Three.js

```javascript
floor = new THREE.Object3D();
scene.add(floor);
    plane = new THREE.Mesh(planeGeom,planeMat);
floor.add(plane)

table = new THREE.Object3D();
scene.add(table);
    bowl = new THREE.Mesh(bowlGeom,bowlMat);
table.add(bowl);

// …
```
How do groups help us with transformations?
- Ten meshes
- One subgroup
- Three groups

Moving a group affects all its components

```plaintext
table.position.x = 15;
chair.rotation.z += 1.6;
```
Questions

1. What principles guide the grouping of objects into a hierarchy?
   *Relatedness is one motivation. Shared motion is another.*

2. What Three.js class is used to represent an object grouping?
   *Object3D*

3. Match the code to the picture.
   
   - A. `Q.add(R); Q.add(S); R.add(T)`
   - B. `R.add(Q); S.add(Q); T.add(R)`
Object Hierarchy

Demo of programming with an object hierarchy

- Motion of **body** object carries all pieces (trunk + both limbs)
- Why do we need **lhip** and **rhip**?
  - Rotation point for the limbs
  - Without it, cube would rotate around its center

\[
C_{\text{Left}} = M_{\text{Body}} M_{\text{LHip}} M_{\text{Left}} \\
C_{\text{Left}} = M_{\text{Body}} T_{\text{LHip}} R_{\text{LHip}} T_{\text{Left}} R_{\text{Left}}
\]
Human Body Model

- LeftHand
- Torso
- RightHand
- LowLeftArm
- UpLeftArm
- UpRightArm
- LowRightArm
- LowLeftLeg
- UpLeftLeg
- UpRightLeg
- LowRightLeg
- LeftFoot
- RightFoot

![Human body model diagram](image)
Use hierarchical structure

- Coordinate system for planet centered on parent
- Planet is offset relative to this
- Rotate coordinates to follow orbit
- Moons move with planet
- Similar strategy for moon orbit
Questions

1. What are the advantages of grouping objects together as children of a virtual object?
   
   They can all be moved and manipulated as a single entity.

2. Besides grouping, what is another reason for having a virtual object in the scene?
   
   We can apply a rotation to a translated piece.
Review

After watching this video you should be able to...

- Propose sensible groupings of objects and object parts
- Build scenes as hierarchies of Object3D
- Employ object hierarchies to efficiently produce a desired animation

Music: [https://www.bensound.com](https://www.bensound.com)