

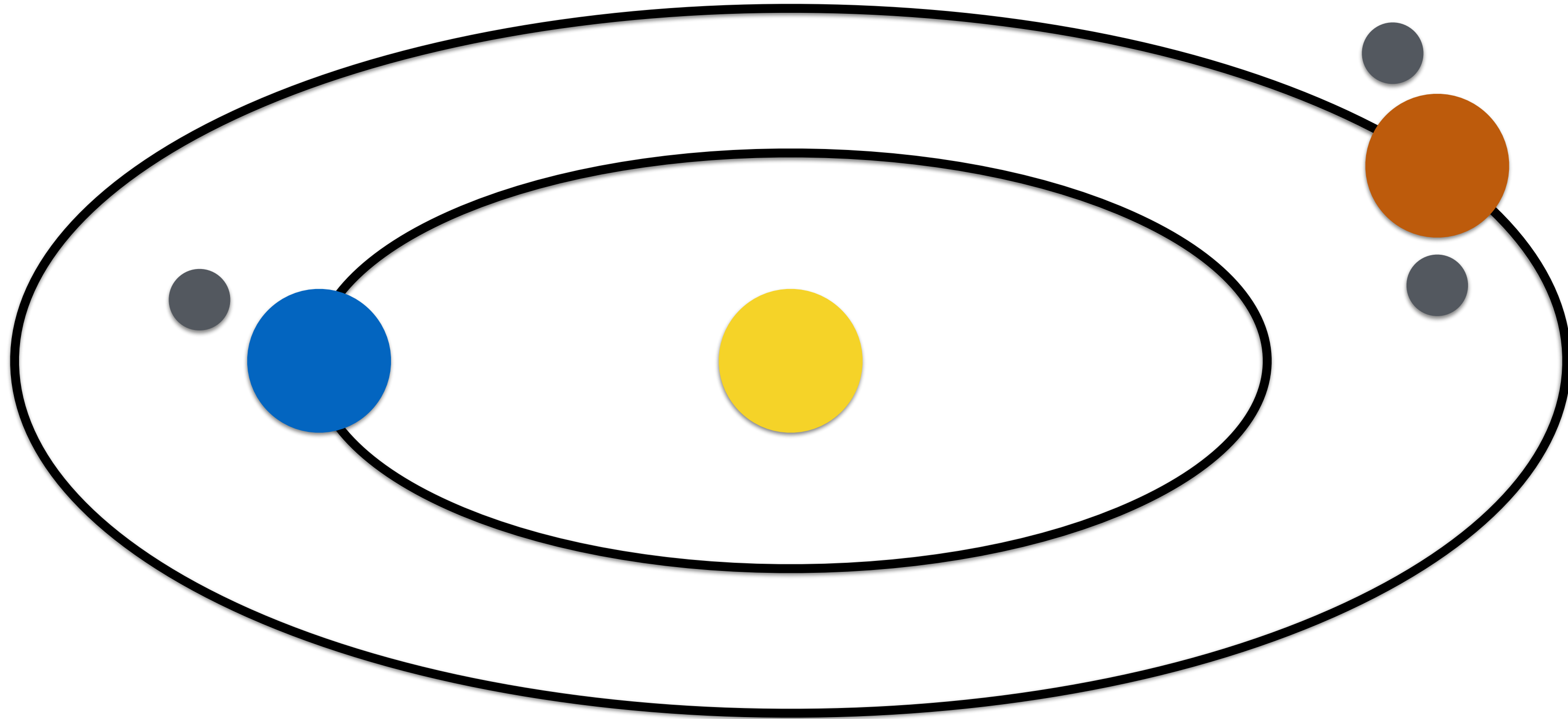


# Transformation Hierarchies

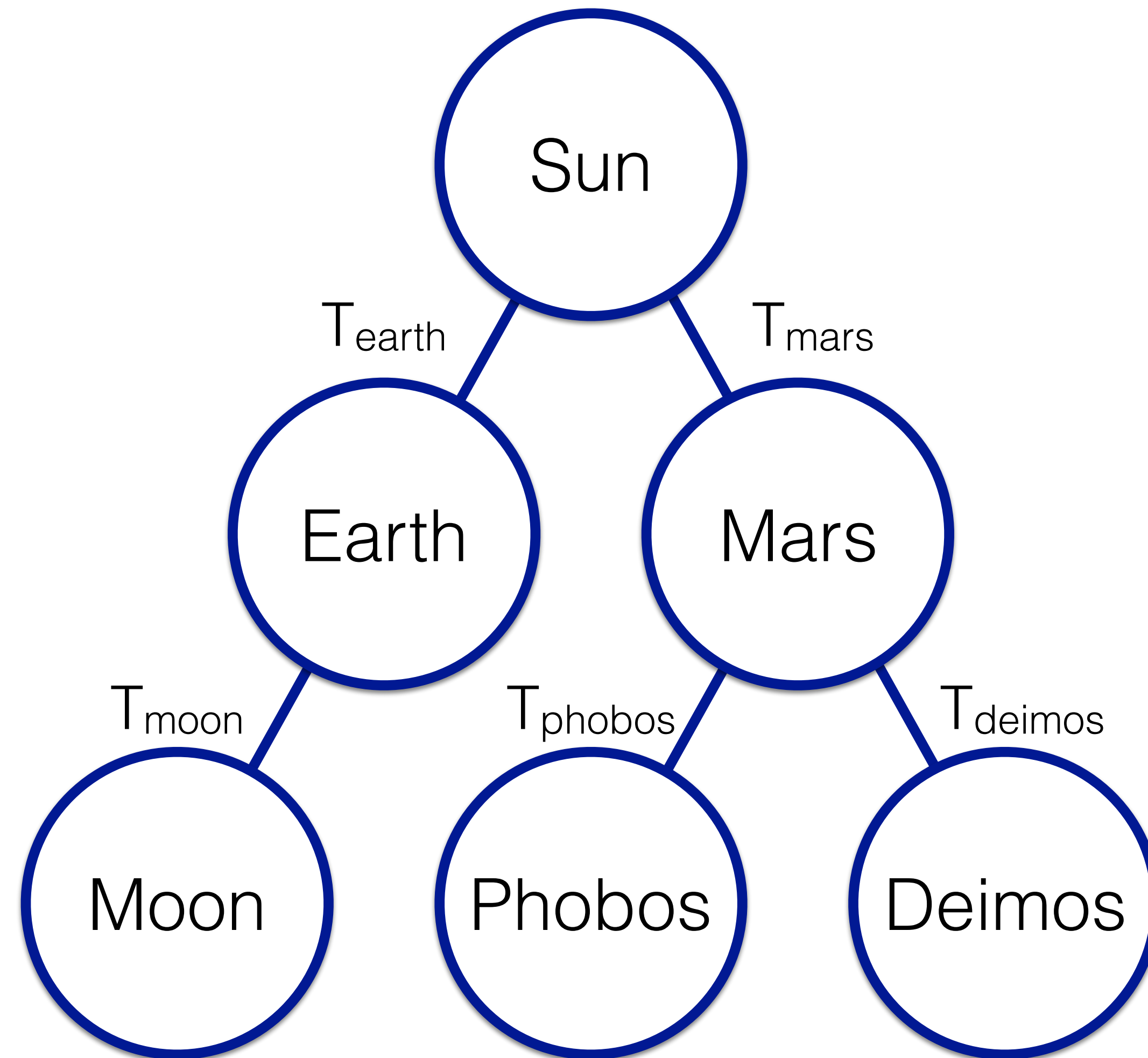
CS 355: Introduction to Graphics and Image Processing



# Object Hierarchies



# Transformation Hierarchies

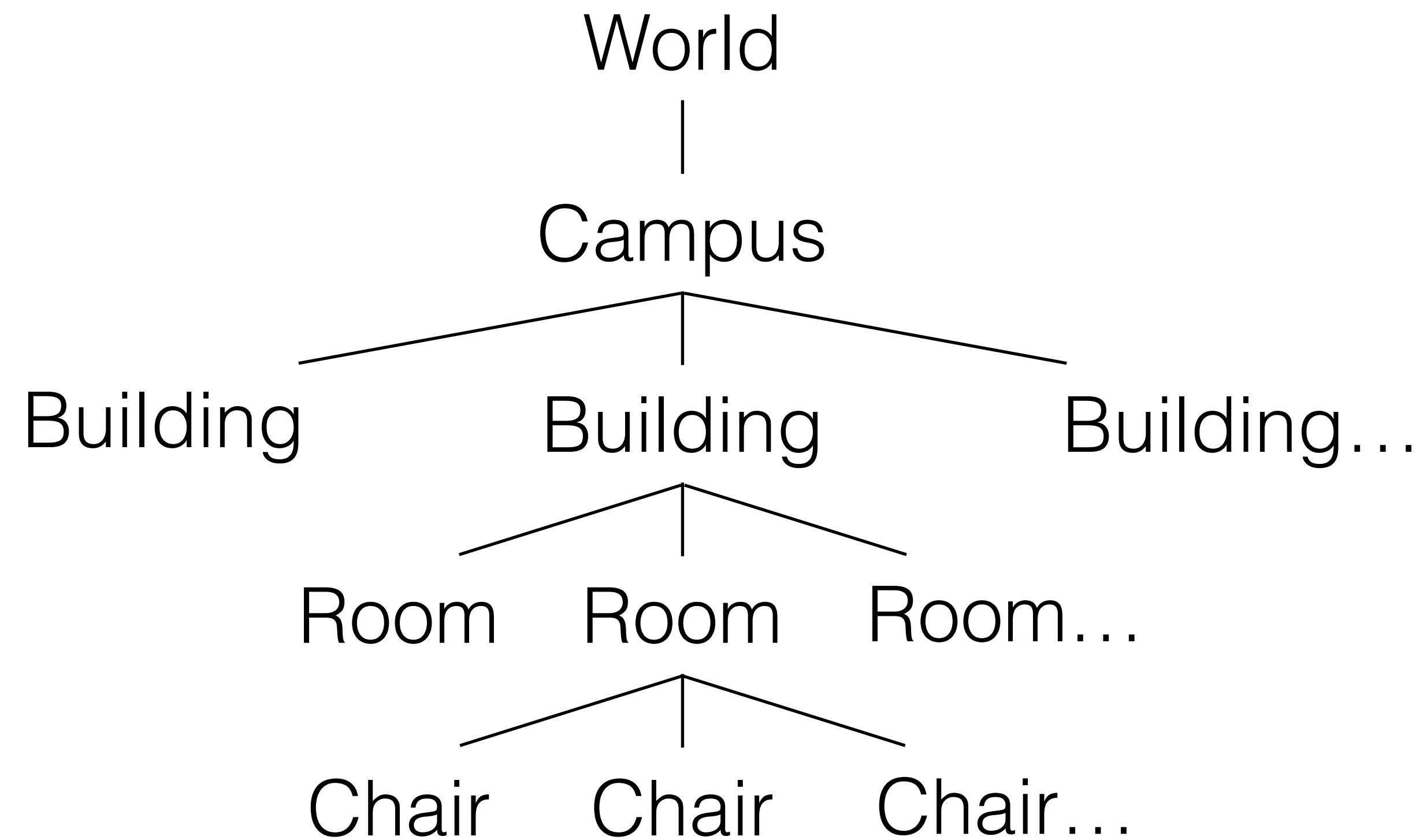




# Hierarchical Models

- Use same model for each chair in the classroom
  - each has a different orientation and position in the room
    - which is oriented and positioned in the building
      - which is oriented and positioned on campus
        - which is oriented and positioned in the world

# Hierarchical Models



# Order of Transformations

$$\text{Chair 1: } \mathbf{p}_{\text{world}} = \mathbf{T}_{\text{campus}} \mathbf{T}_{\text{building}} \mathbf{T}_{\text{room}} \mathbf{T}_{\text{chair}_1} \mathbf{p}$$

$$\text{Chair 2: } \mathbf{p}_{\text{world}} = \mathbf{T}_{\text{campus}} \mathbf{T}_{\text{building}} \mathbf{T}_{\text{room}} \mathbf{T}_{\text{chair}_2} \mathbf{p}$$

$$\text{Chair 3: } \mathbf{p}_{\text{world}} = \mathbf{T}_{\text{campus}} \mathbf{T}_{\text{building}} \mathbf{T}_{\text{room}} \mathbf{T}_{\text{chair}_3} \mathbf{p}$$

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room-to-world

---

chair

# Leveraging Composition

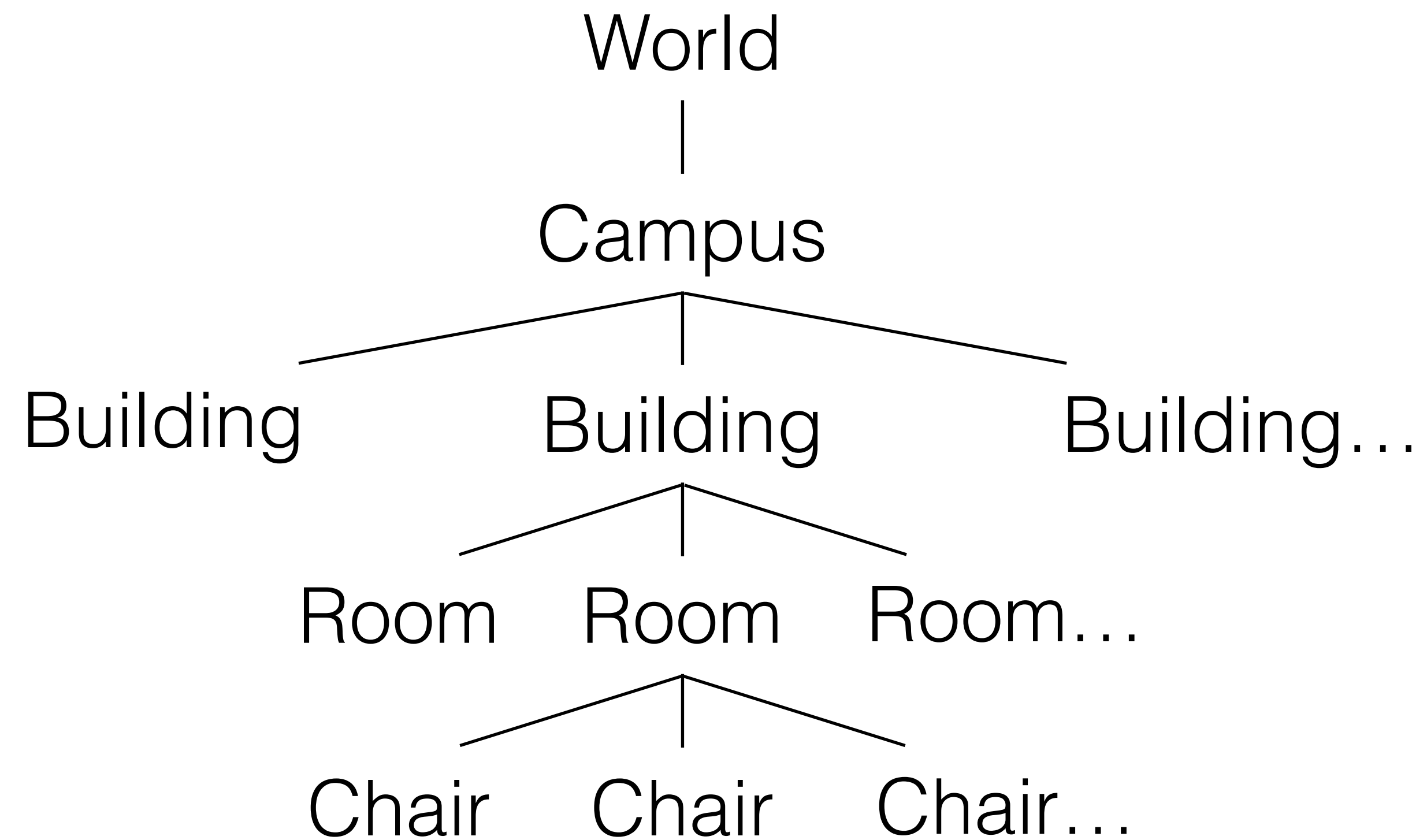
$$\text{Chair 1: } \mathbf{p}_{\text{world}} = (((\mathbf{T}_{\text{campus}} \mathbf{T}_{\text{building}}) \mathbf{T}_{\text{room}}) \mathbf{T}_{\text{chair}_1}) \mathbf{p}$$

$$\text{Chair 2: } \mathbf{p}_{\text{world}} = (((\mathbf{T}_{\text{campus}} \mathbf{T}_{\text{building}}) \mathbf{T}_{\text{room}}) \mathbf{T}_{\text{chair}_2}) \mathbf{p}$$

$$\text{Chair 3: } \mathbf{p}_{\text{world}} = (((\mathbf{T}_{\text{campus}} \mathbf{T}_{\text{building}}) \mathbf{T}_{\text{room}}) \mathbf{T}_{\text{chair}_3}) \mathbf{p}$$



# Hierarchical Models





# Transformation Stacks





# Transformation Stacks

drawCars:

push()

For all cars i

drawCar(i)

pop()

drawCar(i):

push()

concatonate(carTransform[i])

drawCarBody()

for all tires j

drawTire(j)

pop()

drawTire(j):

push()

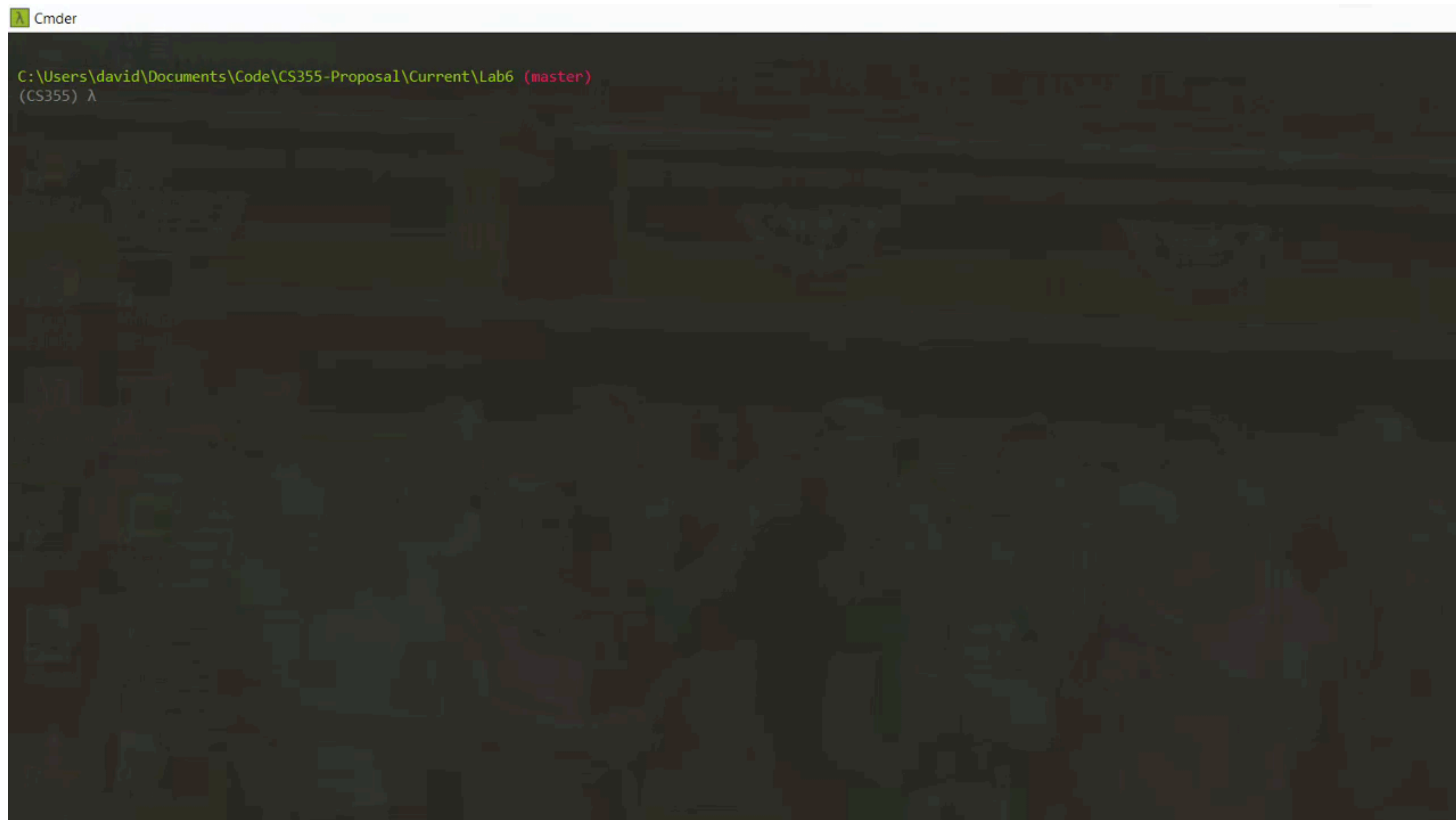
concatonate(tireTransform[j])

drawOneTire()

pop()



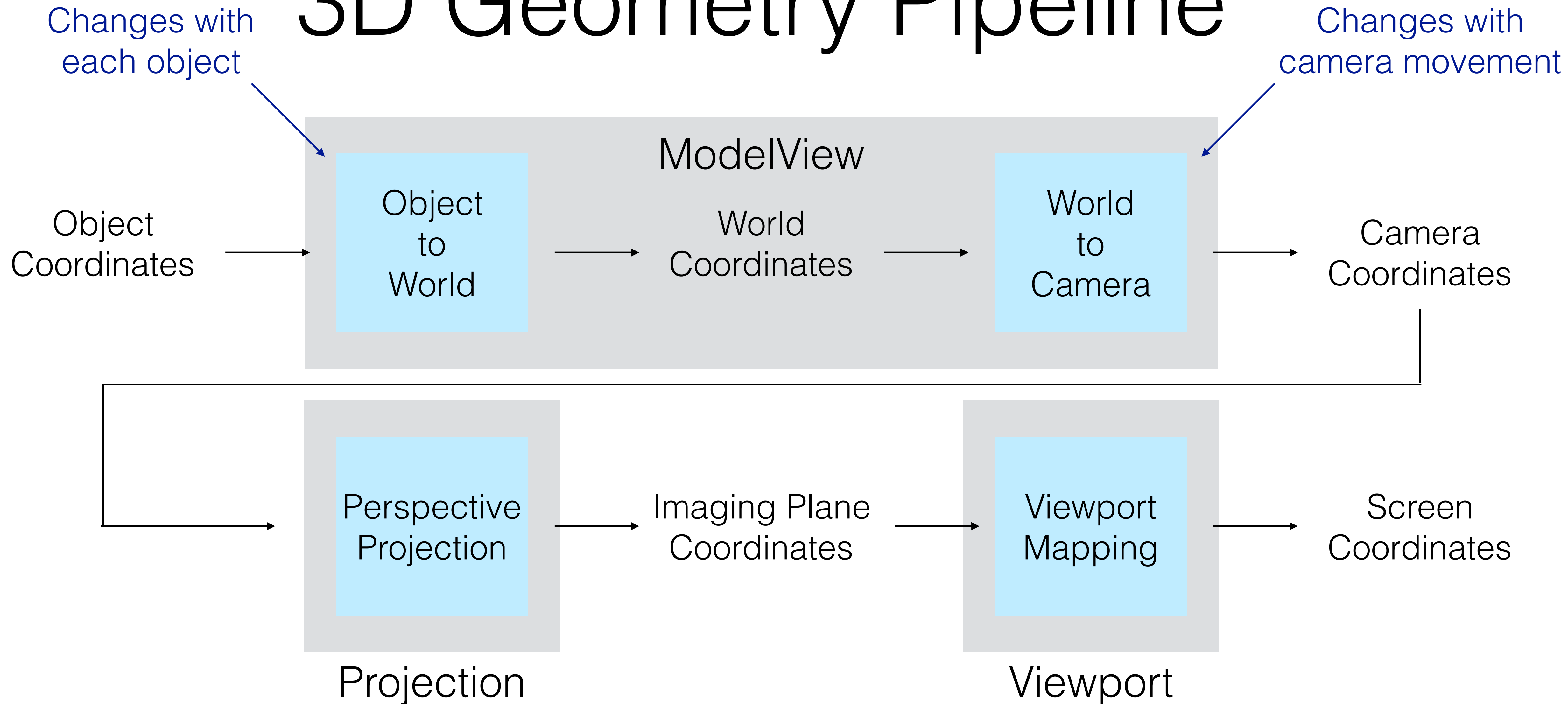
# Lab 6



```
λ C:\Users\david\Documents\Code\CS355-Proposal\Current\Lab6 (master)  
(CS355) λ git checkout 11
```

The screenshot shows a Windows Command Prompt window with a dark background. The title bar at the top reads "λ C:\Users\david\Documents\Code\CS355-Proposal\Current\Lab6 (master)". The command prompt shows the current directory as "C:\Users\david\Documents\Code\CS355-Proposal\Current\Lab6" and the current branch as "(master)". The user has entered the command "git checkout 11", which is displayed in green text. The prompt "(CS355) λ" is shown at the end of the line.

# 3D Geometry Pipeline



# Example

- Load the ModelView matrix with the desired world-to-view transformation
- Here's how you can draw one transformed object:

```
glPushMatrix()  
glTranslate(0,0,40)  
glRotatef(180,0,1,0)  
drawHouse()  
glPopMatrix()
```

- When you're done, the ModelView matrix is restored back
- Repeat for each different object
- Nest for hierarchical objects

# Coming up...

- 3D rendering geometry
  - More details
  - Efficient implementation
- Visibility
- Lighting