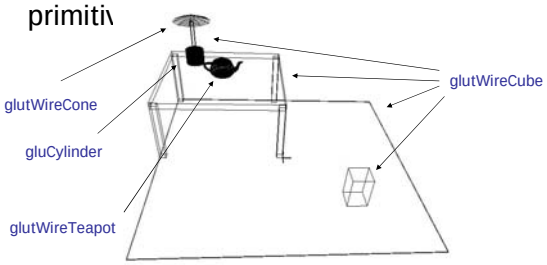
Using GLU/GLUT Objects

- GLU/GLUT provides very simple object primiti



GLU/GLUT Objects

- Each glu/glut object has its default size, position, and orientation
- You need to perform modeling transformation to make it right for you

glutWireCube(1.0) - 'wire' means wire frame

Put a 1x1x1 cube with its center at world (0,0,0)

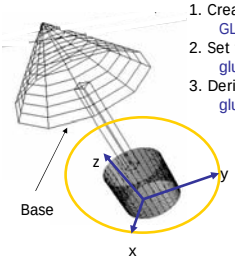
To create a 2 x 0.1 x 2 table top - need to call glScalef(2, 0.1, 2) before you call glutWireCube(1.0)

gluCylinder()

sphere, cylinder, disk, partial disk

- Three steps to create a cylinder

1. Create a GLU quadric object
   GLUquadricObj *p = gluNewQuadric();
2. Set to wire frame mode
   gluQuadricDrawStyle(GLU_LINE);
3. Derive a cylinder object from p
   gluCylinder(p, base, top, height, slice, stacks)

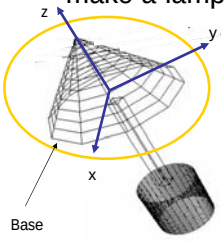


base radius
top radius
height
num. of vertical lines
num. of horizontal lines

The default position is also with base at z = 0 plane

glutWireCone()

- Use glutWireCone and gluCylinder to make a lamp



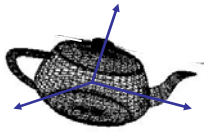
glutWireCone(base, height, slices, stacks)

- A polygon approximation of a cone.

Default position: its base at Z = 0 plane
base: the width of its base
height: the height of the cone
slices: the number of vertical lines used to make up the cone
stace: the number of horizontal lines used to make up the cone

glutWireTeapot()

- The famous Utah Teapot has become an unofficial computer graphics mascot



glutWireTeapot(0.5) -

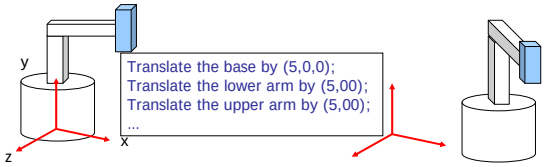
Create a teapot with size 0.5, and position its center at (0,0,0)

Again, you need to apply transformations to position it at the right spot

Transformations

- Two ways to specify transformations
  - (1) Each part of the object is transformed independently relative to the origin

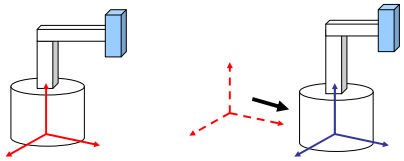
Not the OpenGL Way!



Relative Transformation

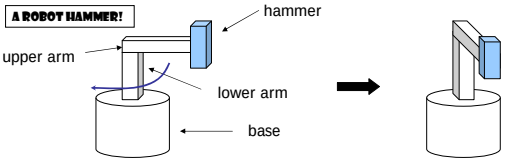
A better (and easier) way:

(2) Relative transformation: Specify the transformation for each object relative to its parent



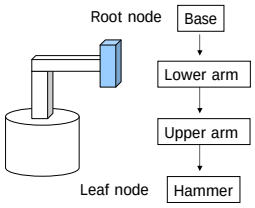
Object Dependency

- A graphical scene often consists of many small objects
- The attributes of an object (positions, orientations) can depend on others



Hierarchical Representation - Scene Graph

- We can describe the object dependency using a tree structure

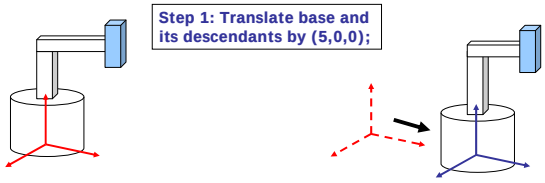


The position and orientation of an object can be affected by its parent, grand-parent, grand-grand-parent ... nodes

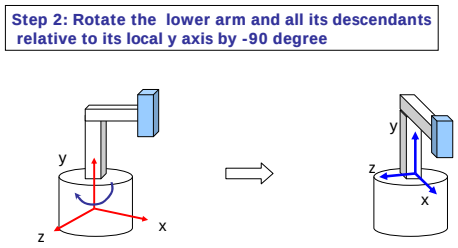
This hierarchical representation is referred to as Scene Graph

Relative Transformation

Relative transformation: Specify the transformation for each object relative to its parent

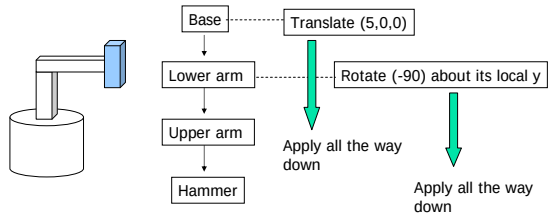


Relative Transformation (2)



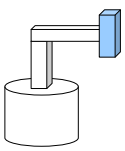
Relative Transformation (3)

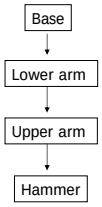
- Represent relative transformations using scene graph



Do it in OpenGL

- Translate base and all its descendants by (5,0,0)
- Rotate the lower arm and its descendants by -90 degree about the local y

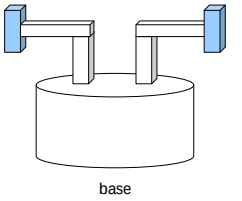




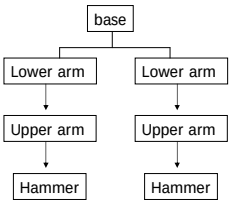

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();

... // setup your camera

glTranslatef(5,0,0);

Draw_base();

glRotatef(-90, 0, 1, 0);

Draw_lower _arm();
Draw_upper_arm();
Draw_hammer();
```

A more complicated example

- How about this model?

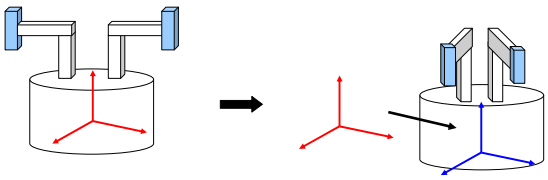


Scene Graph?



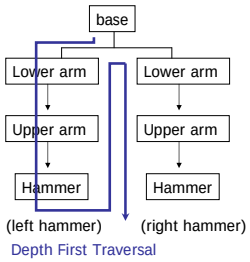
Do this ...

- Base and everything – translate (5,0,0)
- Left hammer – rotate 75 degree about the local y
- Right hammer – rotate -75 degree about the local y

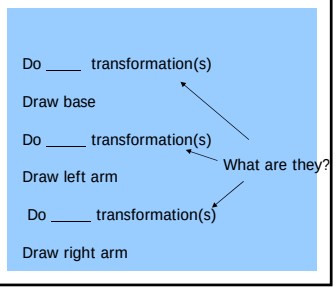


Depth-first traversal

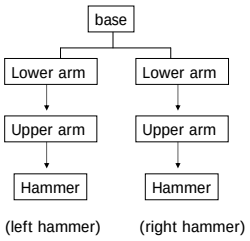
- Program this transformation by depth-first traversal



Depth First Traversal



How about this?



Translate(5,0,0)

Draw base

Rotate(75, 0, 1, 0)

Draw left hammer

What's wrong?!

Rotate(-75, 0, 1, 0)

Draw right hammer

Something is wrong ...

- What's wrong? – We want to transform the right hammer relative to the base, not to the left hammer

How about this?

Do Translate(5,0,0)

Draw base

Do Rotate(75, 0, 1, 0)

Draw left hammer

What's wrong?!

Do Rotate(-75, 0, 1, 0)

Draw right hammer

We should **undo the left hammer transformation** before we transform the right hammer

Need to undo this first

Undo the previous transformation(s)

- Need to save the modelview matrix right after we draw base

Initial modelView M

Translate(5,0,0) -> M = M x T

Draw base

Rotate(75, 0, 1, 0)

Draw left hammer

Rotate(-75, 0, 1, 0)

Draw right hammer

Undo the previous transformation means we want to restore the Modelview Matrix M to what it was here

i.e., save M right here

...

And then restore the saved Modelview Matrix

OpenGL Matrix Stack

- We can use OpenGL Matrix Stack to perform matrix save and restore

Initial modelView M

Do Translate(5,0,0) -> M = M x T

Draw base

Do Rotate(75, 0, 1, 0)

Draw left hammer

Do Rotate(-75, 0, 1, 0)

Draw right hammer

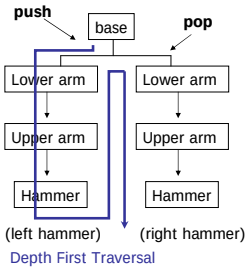
* Store the current modelview matrix
- Make a copy of the current matrix and **push** into OpenGL Matrix Stack call glPushMatrix()

- continue to modify the current matrix

* Restore the saved Matrix
- Pop the top of the Matrix and copy it back to the current Modelview Matrix:
Call glPopMatrix()

Push and Pop Matrix Stack

- A simple OpenGL routine:



Depth First Traversal

```
glTranslate(5,0,0)
Draw_base();
glPushMatrix();

glRotate(75, 0,1,0);
Draw_left_hammer();

glPopMatrix();
glRotate(-75, 0,1,0);
Draw_right_hammer();
```

Push and Pop Matrix Stack

- Nested push and pop operations