# EECS 487

February 14, 2006

- Changli Wang presentation
- SKETCH video
- project 3 concepts
- how to transform a normal vector
- why is n·l correct for diffuse shading?

# JOT: flat scene graph

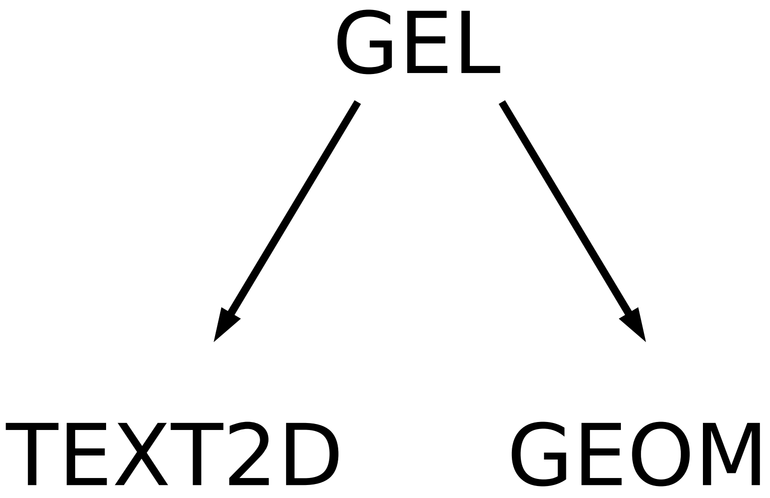
basic type for “geometric elements”: GEL

“scene graph” is just a list of GELs.

each frame:

```
  for (int i=0; i<gels.num(); i++)
      gels[i]->draw();
```

# Derived types



GEL

TEXT2D GEOM

TEXT2D: 2D text displayed in the window

GEOM: Sub-class of GEL that has a mesh, and a transform

# Object space, world space

The transform maps from object space to world space

E.g. a chair model defined near the origin, aligned to major axes (in object space)

To place the chair somewhere in the world, apply a transform to translate, rotate, or scale the shape

# GEOM::draw()

```
GEOM::draw() {
   push current matrix (save on stack)
   multiply current matrix by xform
   draw mesh
   pop matrix (restore old matrix)
}
```

# BMESH delegates to Patch...

```
BMESH::draw() {
   for each patch p
      p->draw();
}
```

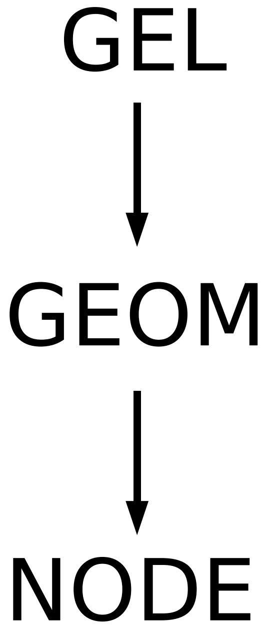
# Patch delegates to GTexture...

```
Patch::draw() {
    find GTexture g matching the name of the current rendering style
    g->draw();
}
```

project 2, shaders.H defines GTextures used in project 2

# project 3: nested scene graph

Project 3 uses a subclass of GEL called NODE that supports a nested scene graph:



GEL

GEOM

NODE

# NODE

Each NODE has:

transform and BMESH (from GEOM)

list of children NODES

pointer to parent NODE

# NODE

For a GEOM, the transform maps from object space to world space

For a NODE, the transform maps from object space to its *parent*'s *object space*

If A is the parent of B, and B is the parent of C, then object-to-world transform for C is:

```
A.xform() * B.xform() * C.xform()
```

# NODE::draw()

```
NODE::draw() {
   push current matrix (saves it)
   multiply current matrix by xform
   draw mesh
   draw each child // new in NODE
   pop matrix (restores old matrix)
}
```

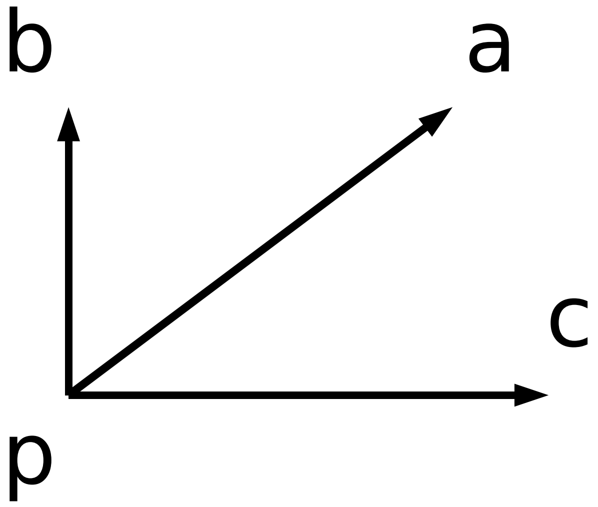
# OpenGL matrix stack

```
Draw A:
   push matrix A on stack
   multiply current matrix by A's xform
   draw A's triangles
   Draw B:
      push matrix B on stack
      multiply current matrix by B's xform
      draw B's triangles
      ...
      pop matrix from stack
   pop matrix from stack
```

# p3: sketching primitives

- Like SKETCH, small number of primitives
  - “cube”
  - cylinder
  - optional: extrude, duct, ...
- Based on user-drawn axes

# Cube primitive



Strokes matching 3 perpendicular axes

# The transform for new cube

map origin to p, and canonical axes {x, y, z} to {a, b, c}:

M = Translate(p) * [a,b,c]

But M maps object space to *world space*. The new cube exists as a child of its parent, which has its *own* transform...

# Cube transform, cont'd

Let P = parent's object-to-world transform

Let M' = matrix to assign to the cube.

Then: $P * M' = M$

so: $M' = P^{-1} * M$

# Cube transform, cont'd

Q: what about scaling?

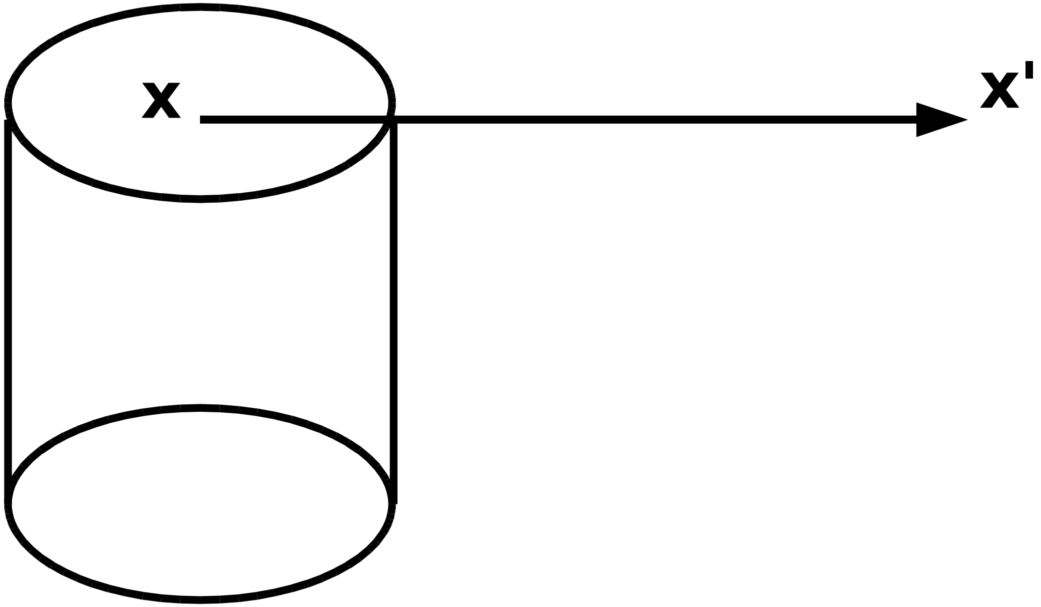
# Cube transform, cont'd

Q: What about scaling?

A: It's built-in.

# Translation: plane constraint

User clicks with middle button, drags



map image-space x and x' to w and w' in parent's object space

translation is: w' – w (in parent's obj. space)

# Translation: plane constraint

```
Wpt p;          // point in plane (object space)
Wvec n;         // plane normal (object space)
XYpt x;         // screen point
Wline R(x);     // ray into scene at x (world space)
Wtransf I;      // world to parent obj. space xform

// find ray intersection with plane:
Wpt w = Wplane(p,n).intersect(I*R);
```

# Translation: line constraint

```
Wpt p;         // point on line (object space)
Wvec n;        // line direction (object space)
XYpt x;        // screen point
Wline R(x);    // ray into scene at x (world space)
Wtransf I;     // world to parent obj. space xform
// find ray intersection with line:
Wpt w = Wline(p,n).intersect(I*R);
```

Q: How to find the intersection of lines in 3D?

Q: How to set transform?

# Translation: line constraint

Q: How to set transform?

A: Find w, w' in parent's object space.
Then replace node's transform M with TM
(T is the translation from w to w')

# transforming normals (board)

# Diffuse shading:
# hack or physically based?

Why is $n \bullet l$ the right number to use for diffuse shading  (aka lambertian shading) (board)

# Midterm

Midterm is in one week.

Homework 2 is assigned today,
due in a week.

Monday: review.
Following week: “spring” break.