COSE436

Lecture 14:
Midterm Review
(Example Questions)

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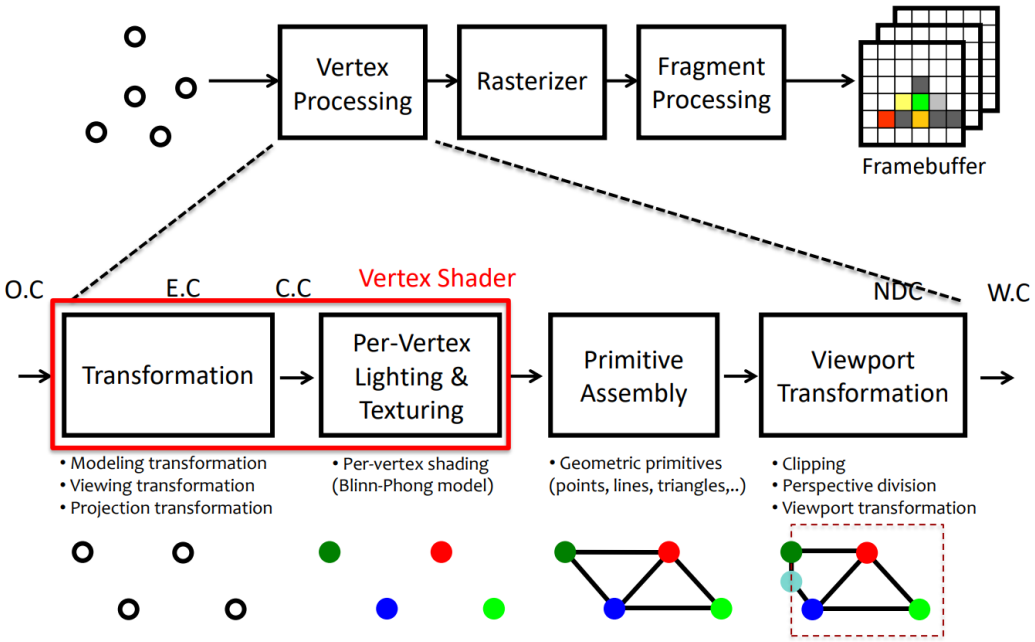
Midterm Exam

- True/False
- Essay (discuss... , explain...)
- Coding/algorithm (fill in the empty lines)

Q1. (20 pts) O / X questions

(a) Ray tracing is a rendering method that can generate global effect, such as multiple reflections and translucent surface rendering.

(b) In the raster graphics pipeline, the clipping stage comes after the rasterization stage.

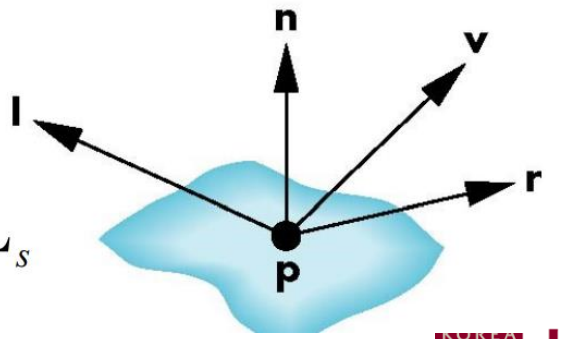


(c) Translation is not a linear transformation.

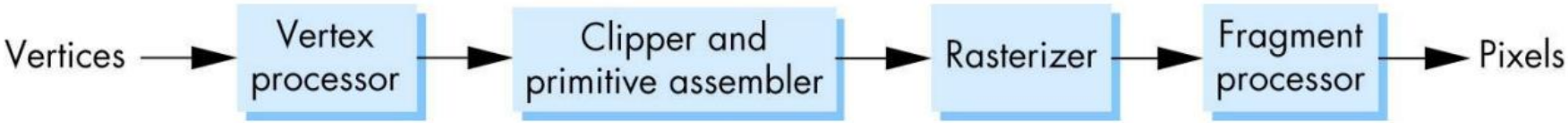
(d) The diffuse term in the Phong illumination model changes if the viewpoint is changed.

- For each light source

$$\mathbf{I} = \mathbf{I}_a + \mathbf{I}_d + \mathbf{I}_s$$
$$= \mathbf{k}_a \mathbf{L}_a + \mathbf{k}_d (\mathbf{l} \cdot \mathbf{n}) \mathbf{L}_d + \mathbf{k}_s (\mathbf{r} \cdot \mathbf{v})^{\alpha} \mathbf{L}_s$$



Raster Graphics Pipeline



Q2. (10 pts) List the following graphics operations in the correct order in the programmable raster graphics pipeline with an early depth test.

(a) Connect vertices to generate triangles.
(b) Interpolate vertex normal to generate per-fragment normal.
(c) Compare the z-value of the current fragment with the value in the depth buffer.
(d) Multiply modelview transformation matrix to the current vertex coordinate.
(e) Divide x/y/z vertex coordinates with w.
(f) Discard primitives that are entirely outside of the clip volume.

Q3. (10 pts) Answer the below questions. Use the definition of linear transformation.

1) $f(x) = Mx$, M is an arbitrary 2x2 matrix, $x \in R^2$. Is $f(x)$ a linear transform? Why or why not?

Q4. (10 pts) Change of coordinate systems.

Let assume that we have the following 2D homogeneous frames A, B and their corresponding coordinates a and b as follows:

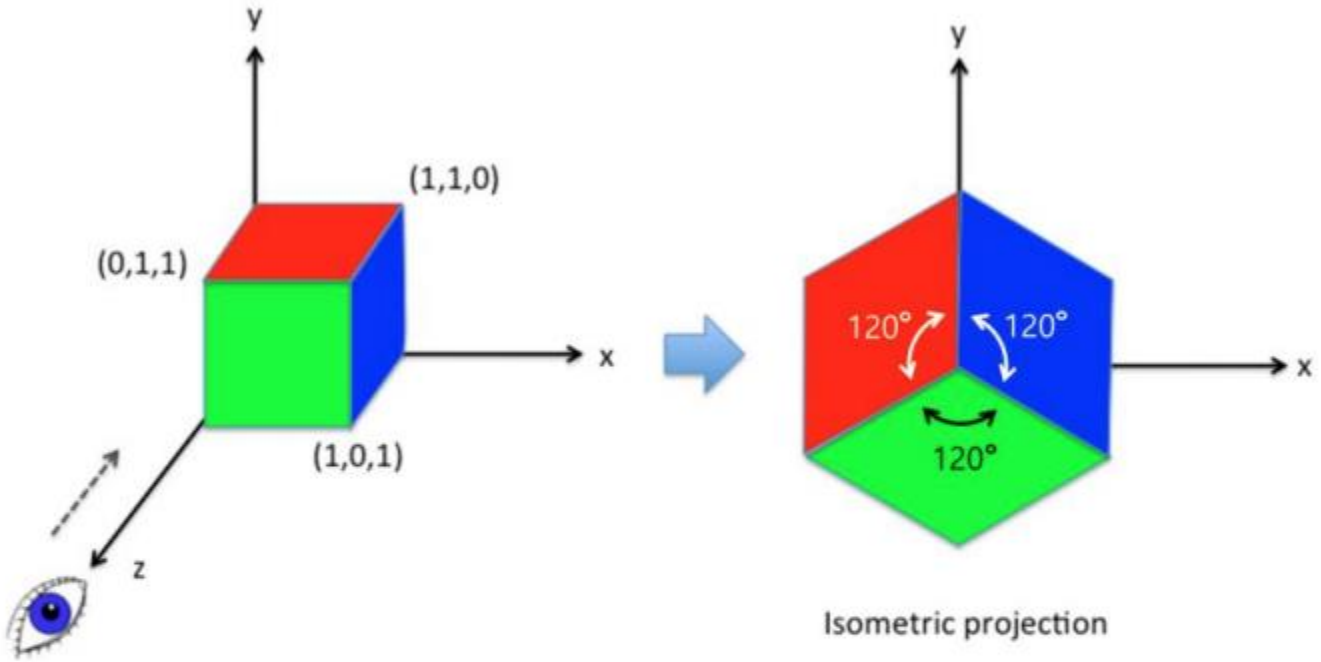
$$\mathrm{A} = \begin{pmatrix} - & v_1 & - \\ - & v_2 & - \\ - & P & - \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad \mathrm{a} = \begin{pmatrix} a_x \\ a_y \\ 1 \end{pmatrix}$$

$$\mathrm{B} = \begin{pmatrix} - & u_1 & - \\ - & u_2 & - \\ - & Q & - \end{pmatrix} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ 2 & 1 & 1 \end{pmatrix}, \quad \mathrm{b} = \begin{pmatrix} b_x \\ b_y \\ 1 \end{pmatrix}$$

Derive a matrix $\bar{\mathrm{M}}$ that converts the coordinate a in the frame A to b in the frame B as follows:

$$\mathrm{b} = \bar{\mathrm{M}}\mathrm{a}$$

Q6. (15 pts) Assume you have a 3D unit cube as shown below left.



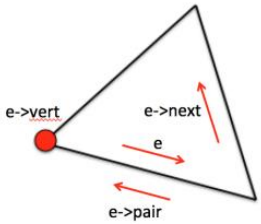
Derive a 4x4 3D modeling transformation matrix in homogeneous coordinates for an isotropic projection (i.e., the angles between the projection of the x, y, and z axes are all the same, or 120°) of a unit cube, as shown above right, by concatenating (multiplying) only two rotation matrices. Assume the viewer's eye location is (0,0,4) and up-vector is (0,1,0), and the projection matrix is an orthogonal projection. Show your work and derive the final matrix.

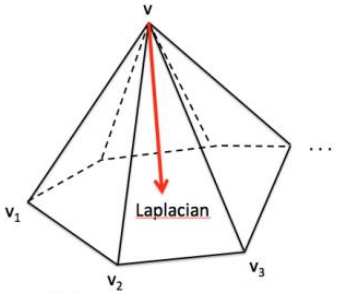
Q8. (20 pts) Complete the below skeleton C code to compute a simple discrete Laplacian (shown right) of a given vertex v using a half-edge triangular mesh data structure (given below). Assume the edge link in the vertex struct is the edge starting from it, the vertex link in the edge struct is the starting vertex of that edge, and there is no boundary edge.

```
struct HE_edge
{
    HE_vert *vert;
    HE_face *face;
    HE_edge *pair;
    HE_edge *next;
};
```

```
struct HE_face
{
    HE_edge *edge;
};

struct HE_vert
{
    Vec3 v;
    HE_edge *edge;
};
```





$$L(v) = \frac{1}{N}\sum_{i=1}^{N}(v_i - v), \quad v_i = \text{adjacent neighbor of } v$$

```
Vec3 Laplacian(HE_vert *v)
{
      Vec3 L = Vec3(0,0,0);
      int N = 0;
      HE_edge* currE = v->edge;
      HE_vert* startV = currE->next->vert;
      while(1)
      {
            L += (currE-> _____ - v->v);
            N++;
            currE = _____;
            if(startV == _____ ) break;
      }
      L = L/N;
      return L;
}
```

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Questions?