CSE4204

LAB-3 : Index buffer and Transformation Matrices

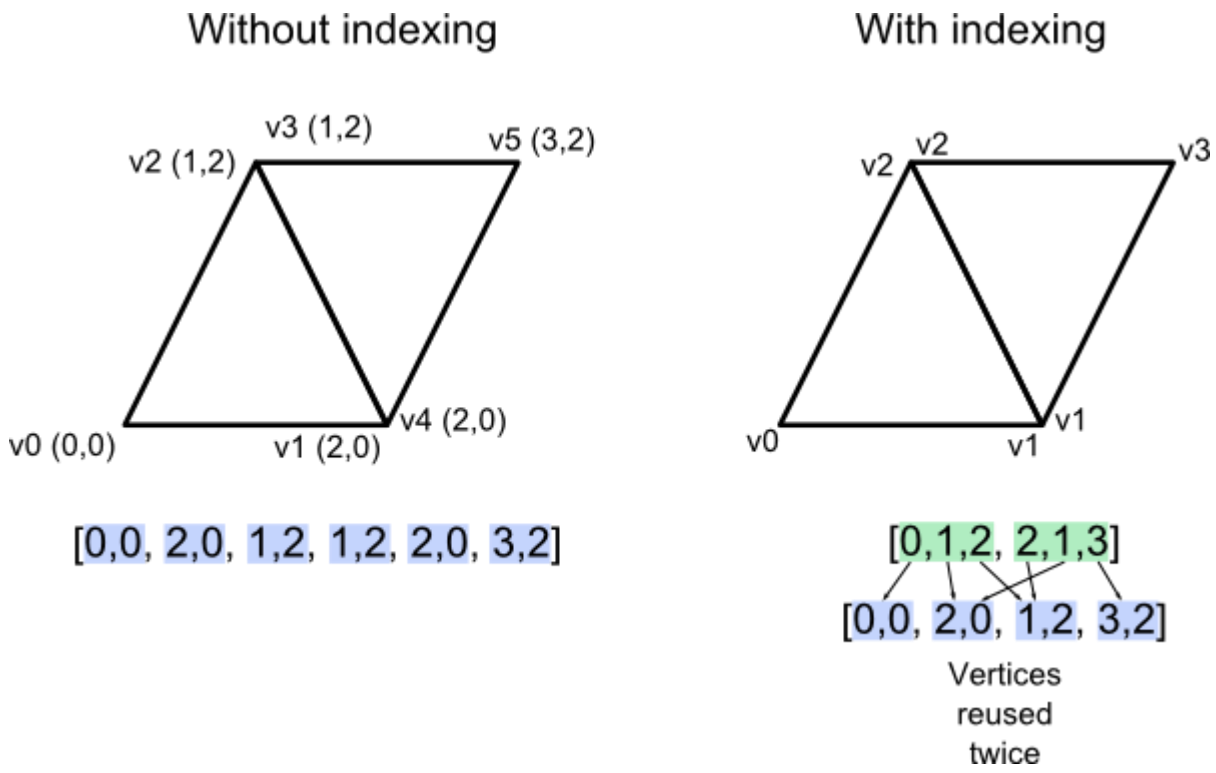
Mohammad Imrul Jubair

Recap: Uniform vs Attribute vs Varying

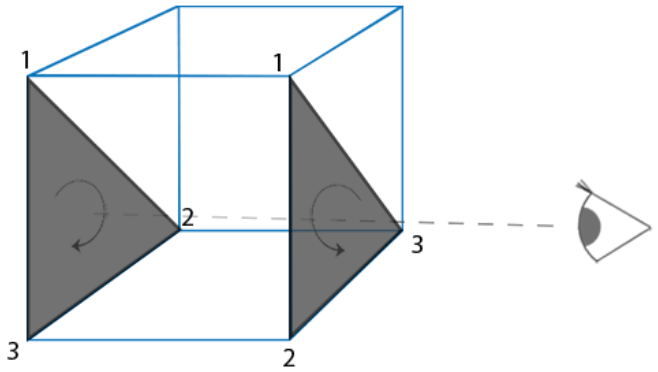
- uniform are per-primitive parameters
  - constant during an entire draw call
- attribute are per-vertex parameters
  - typically : positions, normals, colors, UVs, ...
- varying are per-fragment (or per-pixel) parameters
  - they vary from pixels to pixels

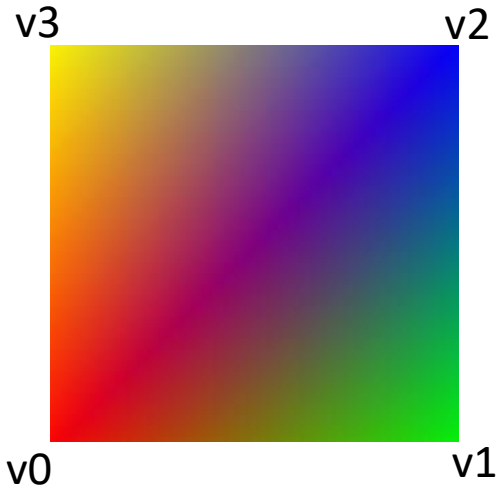
Source: https://stackoverflow.com/questions/17537879/in-webgl-what-are-the-differences-between-an-attribute-a-uniform-and-a-varying

Index Buffer



Index Buffer

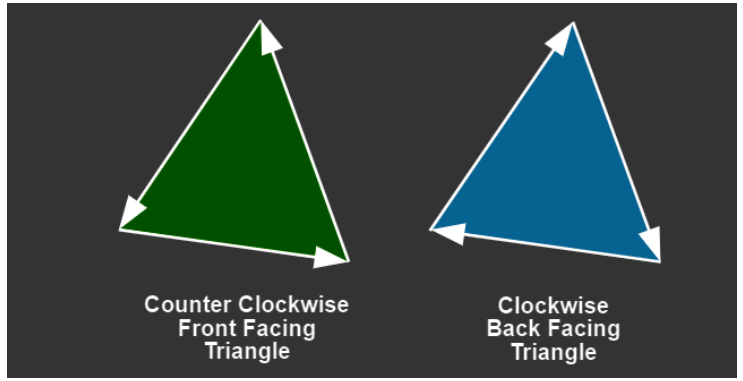





```
var coords = new Float32Array( [
                    -0.5, -0.5,  0.0, //v0
                     0.5, -0.5,  0.0, //v1
                     0.5,  0.5,  0.0, //v2
                    -0.5,  0.5,  0.0  //v3
                                    ] );
```

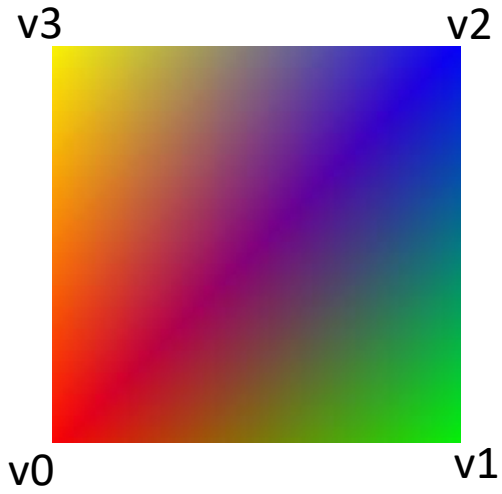
```
var colors = new Float32Array( [
                    1.0, 0.0, 0.0, //color at v0
                    0.0, 1.0, 0.0, //color at v1
                    0.0, 0.0, 1.0, //color at v2
                    1.0, 1.0, 0.0 //color at v3
                                ] );
```

```
var indices = new Uint8Array([0, 1, 2,  0, 2, 3]);
```



https://webglfundamentals.org/webgl/lessons/webgl-3d-orthographic.html

Index Buffer




```
var coords = new Float32Array( [
                    -0.5, -0.5,  0.0, //v0
                     0.5, -0.5,  0.0, //v1
                     0.5,  0.5,  0.0, //v2
                    -0.5,  0.5,  0.0  //v3
                                    ] );
```

```
var colors = new Float32Array( [
                        1.0, 0.0, 0.0, //color at v0
                        0.0, 1.0, 0.0, //color at v1
                        0.0, 0.0, 1.0, //color at v2
                        1.0, 1.0, 0.0 //color at v3
                                    ] );
```

```
var indices = new Uint8Array([0, 1, 2,  0, 2, 3]);
```

```
var bufferInd = gl.createBuffer();
gl.bindBuffer(gl.ELEMENT_ARRAY_BUFFER, bufferInd);
gl.bufferData(gl.ELEMENT_ARRAY_BUFFER, indices, gl.STATIC_DRAW);
```

```
//gl.drawArrays(gl.TRIANGLES, 0, 3);
gl.drawElements(gl.TRIANGLES, 3*2, gl.UNSIGNED_BYTE, 0);
```

Get the code

rb.gy/pnoyvj

Transformation Matrix

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$$V' = S \times V$$

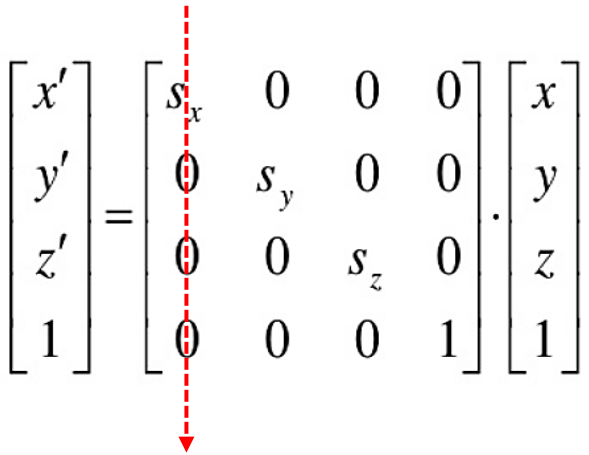
```
var vertexShaderSource =
    `attribute vec3 a_coords;
    attribute vec3 a_colors;
    uniform mat4 u_Scale;
    varying vec3 v_color;

    void main() {
        gl_Position = u_Scale*vec4(a_coords, 1.0);
        v_color = a_colors;
    }`;
```

Scale Matrix

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

```
u_scale_location = gl.getUniformLocation(prog, "u_Scale");
var Sx = 1.5;
var Sy = 0.75;
var Sz = 1.0;
var scaleMatrix = new Float32Array( [Sx,   0.0,  0.0,  0.0,
                                     0.0,  Sy,   0.0,  0.0,
                                     0.0,  0.0,  Sz,   0.0,
                                     0.0,  0.0,  0.0,  1.0] );

gl.uniformMatrix4fv(u_scale_location, false, scaleMatrix);
```

Column Major

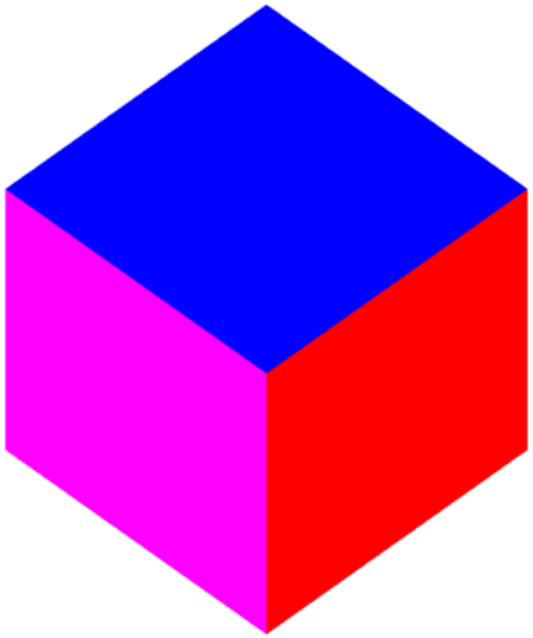



```
u_scale_location = gl.getUniformLocation(prog, "u_Scale");
var Sx = 1.5;
var Sy = 0.75;
var Sz = 1.0;
var scaleMatrix = new Float32Array( [Sx,  0.0,  0.0,  0.0,
                                     0.0,  Sy,   0.0,  0.0,
                                     0.0,  0.0,  Sz,   0.0,
                                     0.0,  0.0,  0.0,  1.0] );

gl.uniformMatrix4fv(u_scale_location, false, scaleMatrix);
```

Get the code

rb.gy/1zrhvj

3D Cube

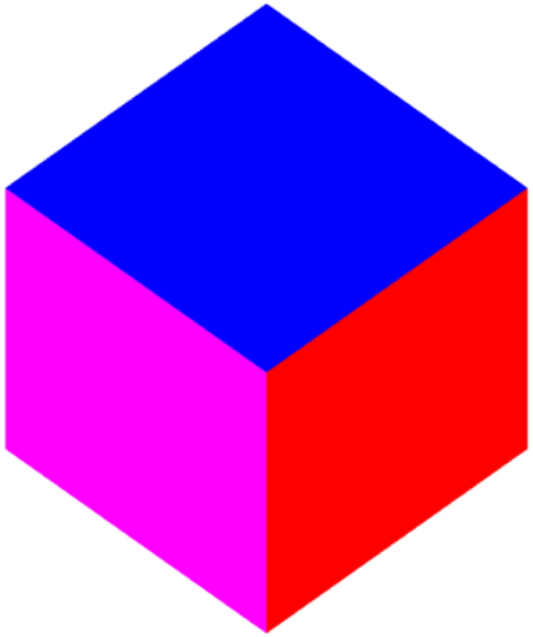


```
var indices = new Uint8Array([
        0, 1, 2,      0, 2, 3,    // Front face
        4, 5, 6,      4, 6, 7,    // Back face
        8, 9, 10,     8, 10, 11,  // Top face
        12, 13, 14,   12, 14, 15, // Bottom face
        16, 17, 18,   16, 18, 19, // Right face
        20, 21, 22,   20, 22, 23  // Left face
    ]);
```

```
var coords = new Float32Array( [
                 // Front face
                -0.5, -0.5,  0.5,
                 0.5, -0.5,  0.5,
                 0.5,  0.5,  0.5,
                -0.5,  0.5,  0.5,

                // Back face
                -0.5, -0.5, -0.5,
                -0.5,  0.5, -0.5,
                 0.5,  0.5, -0.5,
                 0.5, -0.5, -0.5,

                // Top face
                -0.5,  0.5, -0.5,
                -0.5,  0.5,  0.5,
                 0.5,  0.5,  0.5,
                 0.5,  0.5, -0.5,

                // Bottom face
                -0.5, -0.5, -0.5,
                 0.5, -0.5, -0.5,
                 0.5, -0.5,  0.5,
                -0.5, -0.5,  0.5,

                // Right face
                 0.5, -0.5, -0.5,
                 0.5,  0.5, -0.5,
                 0.5,  0.5,  0.5,
                 0.5, -0.5,  0.5,

                // Left face
                -0.5, -0.5, -0.5,
                -0.5, -0.5,  0.5,
                -0.5,  0.5,  0.5,
                -0.5,  0.5, -0.5
                                    ] );
```

```
var colors = new Float32Array( [
        1.0, 0.0, 0.0,
        1.0, 0.0, 0.0,
        1.0, 0.0, 0.0,
        1.0, 0.0, 0.0,

        0.0, 1.0, 0.0,
        0.0, 1.0, 0.0,
        0.0, 1.0, 0.0,
        0.0, 1.0, 0.0,

        0.0, 0.0, 1.0,
        0.0, 0.0, 1.0,
        0.0, 0.0, 1.0,
        0.0, 0.0, 1.0,

        1.0, 1.0, 0.0,
        1.0, 1.0, 0.0,
        1.0, 1.0, 0.0,
        1.0, 1.0, 0.0,

        0.0, 1.0, 1.0,
        0.0, 1.0, 1.0,
        0.0, 1.0, 1.0,
        0.0, 1.0, 1.0,

        1.0, 0.0, 1.0,
        1.0, 0.0, 1.0,
        1.0, 0.0, 1.0,
        1.0, 0.0, 1.0
        ] );
```

Depth Test + Face Culling



```
gl.clearColor(1.0, 1.0, 1.0, 1.0);
gl.enable(gl.DEPTH_TEST);
gl.enable(gl.CULL_FACE);
gl.clear(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT);
gl.drawElements(gl.TRIANGLES, 3*12, gl.UNSIGNED_BYTE, 0);
```

Rotation in 3D

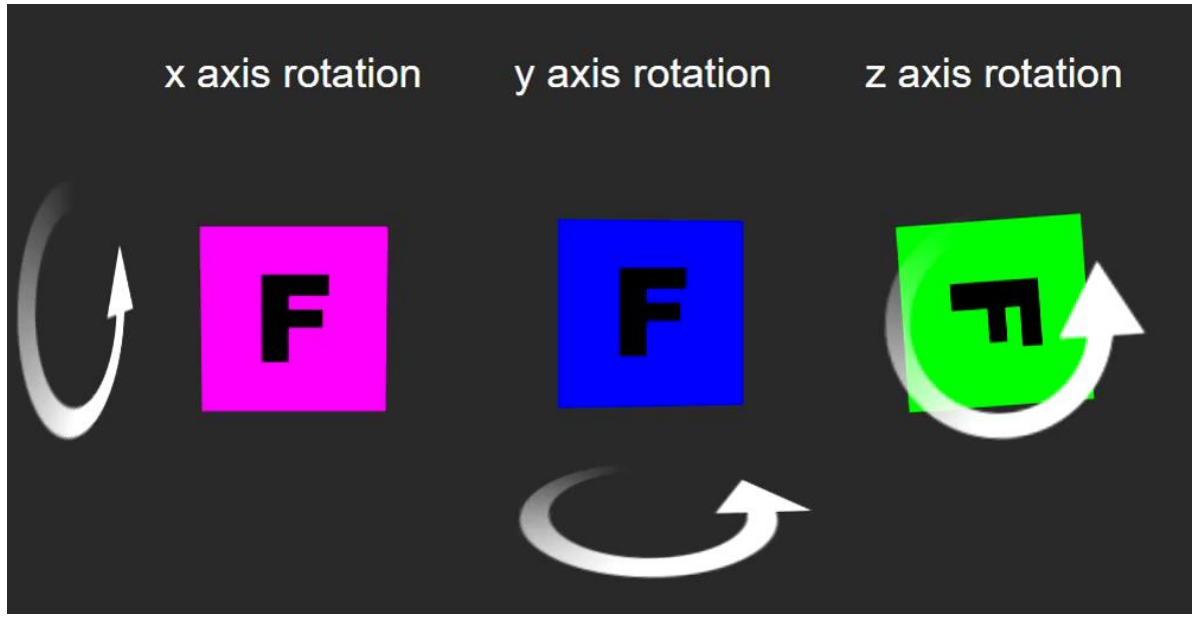
CCW → +ve rotation

$$R_x(\alpha) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha & 0 \\ 0 & \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R_y(\beta) = \begin{bmatrix} \cos\beta & 0 & \sin\beta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\beta & 0 & \cos\beta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R_z(\gamma) = \begin{bmatrix} \cos\gamma & -\sin\gamma & 0 & 0 \\ \sin\gamma & \cos\gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\boldsymbol{V' = R \times V}$$



Rotation in 3D

```
var vertexShaderSource =
    `attribute vec3 a_coords;
    attribute vec3 a_colors;
    uniform mat4 u_RotY;
    varying vec3 v_color;

    void main() {
        gl_Position = u_RotY*vec4(a_coords, 1.0);
        v_color = a_colors;
    }`;
```

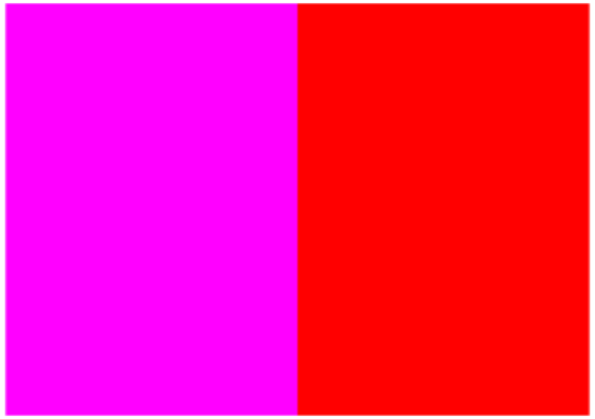
$$V' = R_y \times V$$

Rotation in 3D

$$R_y(\beta) = \begin{bmatrix} \cos\beta & 0 & \sin\beta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\beta & 0 & \cos\beta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
var u_rotateY_location = gl.getUniformLocation(prog, "u_RotY");

var thetaY = 45;
var rad = thetaY*Math.PI/180;
var rotateYMatrix = new Float32Array( [
        Math.cos(rad),  0.0,  -Math.sin(rad),  0.0,
        0.0,            1.0,   0.0,            0.0,
        Math.sin(rad),  0.0,   Math.cos(rad),  0.0,
        0.0,            0.0,   0.0,            1.0 ] );

gl.uniformMatrix4fv(u_rotateY_location, false, rotateYMatrix);
```

Rotation in 3D



```
var u_rotateY_location = gl.getUniformLocation(prog, "u_RotY");

var thetaY = 45;
var rad = thetaY*Math.PI/180;
var rotateYMatrix = new Float32Array( [
        Math.cos(rad),  0.0,  -Math.sin(rad),  0.0,
        0.0,            1.0,   0.0,            0.0,
        Math.sin(rad),  0.0,   Math.cos(rad),  0.0,
        0.0,            0.0,   0.0,            1.0 ] );

gl.uniformMatrix4fv(u_rotateY_location, false, rotateYMatrix);
```

Get the code

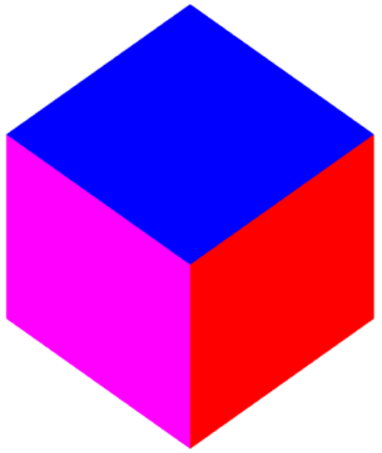
rb.gy/ah1cft

Composite Transformation

$$V' = R_x \times R_y \times V$$

```
var vertexShaderSource =
    `attribute vec3 a_coords;
    attribute vec3 a_colors;
    uniform mat4 u_RotY;
    uniform mat4 u_RotX;
    varying vec3 v_color;

    void main() {
        gl_Position = u_RotX*u_RotY*vec4(a_coords, 1.0);
        v_color = a_colors;
    }`;
```

Composite Transformation



```
var u_rotateY_location = gl.getUniformLocation(prog, "u_RotY");
var thetaY = 45;
var rad = thetaY*Math.PI/180;
var rotateYMatrix = new Float32Array( [Math.cos(rad),  0.0,  -Math.sin(rad),  0.0,
                                       0.0,            1.0,   0.0,            0.0,
                                       Math.sin(rad),  0.0,   Math.cos(rad),  0.0,
                                       0.0,            0.0,   0.0,            1.0] );

gl.uniformMatrix4fv(u_rotateY_location, false, rotateYMatrix);

var u_rotateX_location = gl.getUniformLocation(prog, "u_RotX");
var thetaX = 45;
var rad = thetaX*Math.PI/180;
var rotateXMatrix = new Float32Array( [1.0,  0.0,            0.0,            0.0,
                                       0.0,  Math.cos(rad),  Math.sin(rad),  0.0,
                                       0.0, -Math.sin(rad),  Math.cos(rad),  0.0,
                                       0.0,  0.0,            0.0,            1.0] );
gl.uniformMatrix4fv(u_rotateX_location, false, rotateXMatrix);
```

Get the code

rb.gy/1zmo7c

Composite Transformation

- Example

$$V' = R_x \times R_y \times S \times V$$