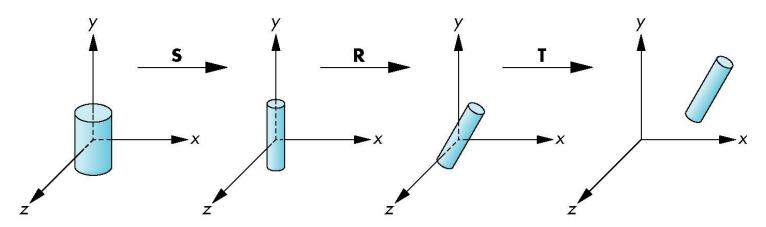
Hierarchical Modeling

14TH WEEK, 2022



Instance Transformation

- Start with a prototype object (a <u>symbol</u>)
- Each appearance of the object in the model is an *instance*
 - Must scale, orient, position
 - Defines instance transformation



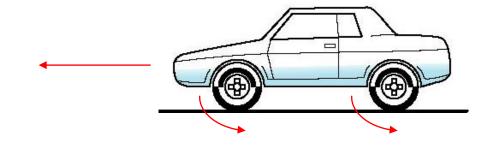
Symbol-Instance Table

• Can store a model by assigning a number to each symbol and storing the parameters for the instance transformation

Symbol	Scale	Rotate	Translate
1	$s_{x'} s_{y'} s_{z}$	$\theta_{x'} \theta_{y'} \theta_{z}$	d_x, d_y, d_z
2	,		,
3			
1			
1			

Relationships in Car Model

- Symbol-instance table does not show relationships between parts of model
- Consider model of car
 - Chassis + 4 identical wheels
 - Two symbols



Rate of forward motion determined by rotational speed of wheels

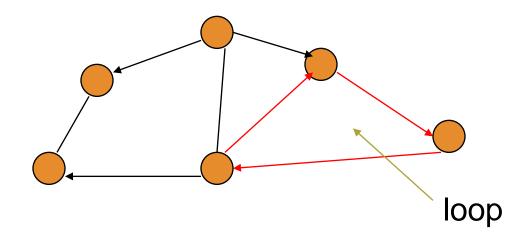
Structure Through Function Calls

```
car(speed)
{
    chassis()
    wheel(right_front);
    wheel(left_front);
    wheel(right_rear);
    wheel(left_rear);
}
```

- Fails to show relationships well
- Look at problem using a graph

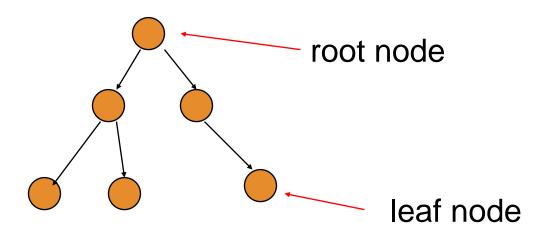
Graphs

- Set of *nodes* and *edges* (*links*)
- Each connects a pair of nodes
 - Directed or undirected
- Cycle: directed path that is a loop

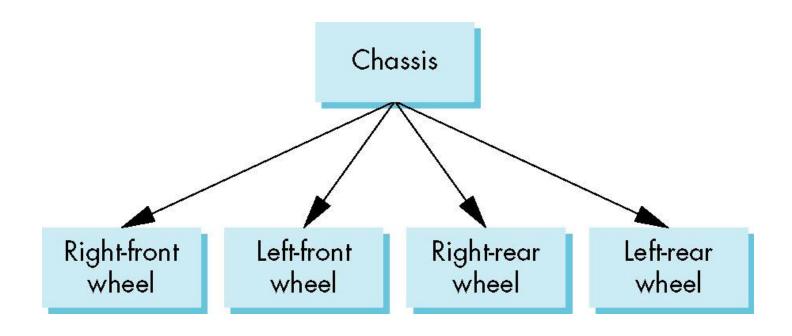


Trees

- Graph in which each node (except the root) has exactly one parent node
 - May have multiple children
 - Leaf or terminal node: no children

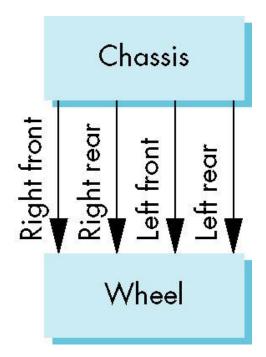


Tree Model of Car



DAG Model

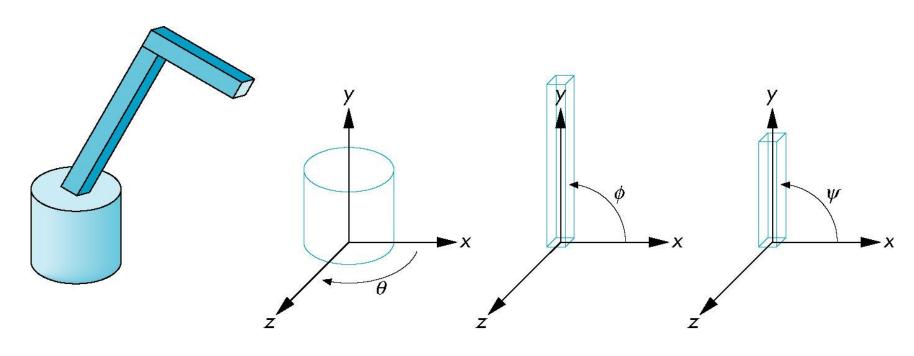
- If we use the fact that all wheels are identical, we get a directed acyclic graph
 - Not much different that dealing with a tree



Modeling with Trees

- Must decide what information to place in nodes and what to put in edges
- Nodes
 - What to draw
 - Pointers to children
- Edges
 - May have information on incremental changes to transformation matrices (can also store in nodes)

Robot Arm

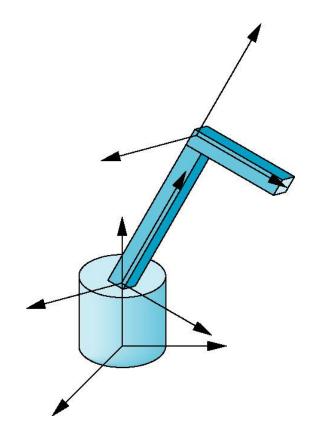


robot arm

parts in their own coodinate systems

Articulated Models

- Robot arm is an example of an <u>articulated model</u>
 - Parts connected at joints
 - Can specify state of model by giving all joint angles



Relationships in Robot Arm

- Base rotate independently
 - Single angle determines position
- Lower arm attached to base
 - Its position depends on rotation of base
 - Must also translate relative to base and rotate about connecting joint
- Upper arm attached to lower arm
 - Its position depends on both base and lower arm
 - Must translate relative to lower arm and rotate about joint connecting to lower arm

Required Matrices

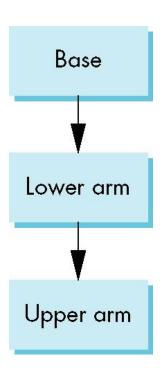
- Rotation of base: \mathbf{R}_{b}
 - Apply $\mathbf{M} = \mathbf{R}_{b}$ to base
- Translate lower arm <u>relative</u> to base: T_{lu}
- Rotate lower arm around joint: \mathbf{R}_{lu}
 - Apply $\mathbf{M} = \mathbf{R}_b \, \mathbf{T}_{lu} \, \mathbf{R}_{lu}$ to lower arm
- Translate upper arm relative to lower arm: \mathbf{T}_{uu}
- Rotate upper arm around joint: \mathbf{R}_{uu}
 - Apply $\mathbf{M} = \mathbf{R}_b \mathbf{T}_{lu} \mathbf{R}_{lu} \mathbf{T}_{uu} \mathbf{R}_{uu}$ to upper arm

WebGL Code for Robot

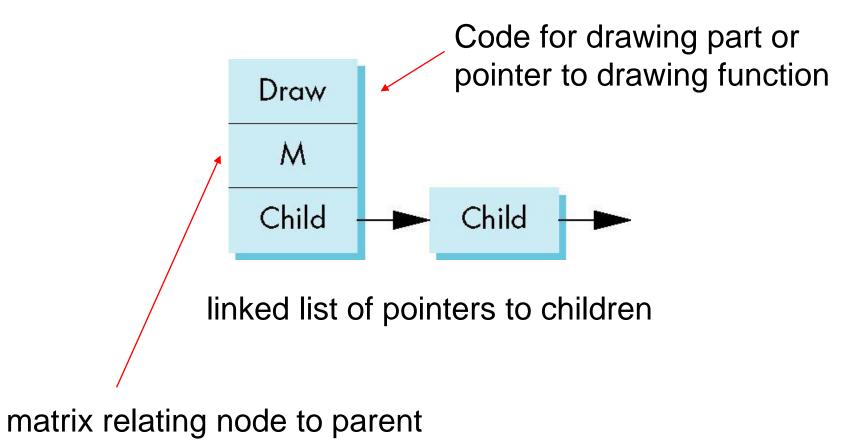
```
var render = function() {
    gl.clear( gl.COLOR BUFFER BIT | gl.DEPTH BUFFER BIT );
    modelViewMatrix = rotate(theta[Base], 0, 1, 0);
   base();
    modelViewMatrix = mult(modelViewMatrix, translate(0.0, BASE HEIGHT, 0.0));
    modelViewMatrix = mult(modelViewMatrix, rotate(theta[LowerArm], 0, 0, 1));
    lowerArm();
   modelViewMatrix = mult(modelViewMatrix, translate(0.0, LOWER ARM HEIGHT, 0.0));
                     = mult(modelViewMatrix, rotate(theta[UpperArm], 0, 0, 1));
    modelViewMatrix
    upperArm();
    requestAnimFrame (render);
```

Tree Model of Robot

- Note code shows relationships between parts of model
 - Can change "look" of parts easily without altering relationships
- Simple example of tree model
- Want a general node structure for nodes



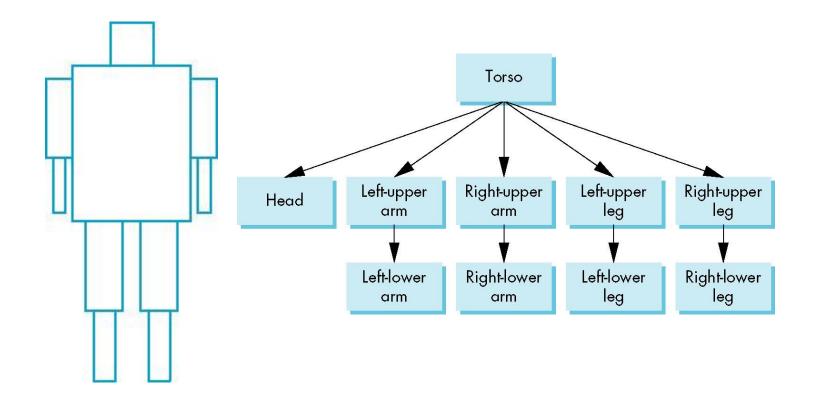
Possible Node Structure



Generalizations

- Need to deal with multiple children
 - How do we represent a more general tree?
 - How do we traverse such a data structure?
- Animation
 - How to use dynamically?
 - Can we create and delete nodes during execution?

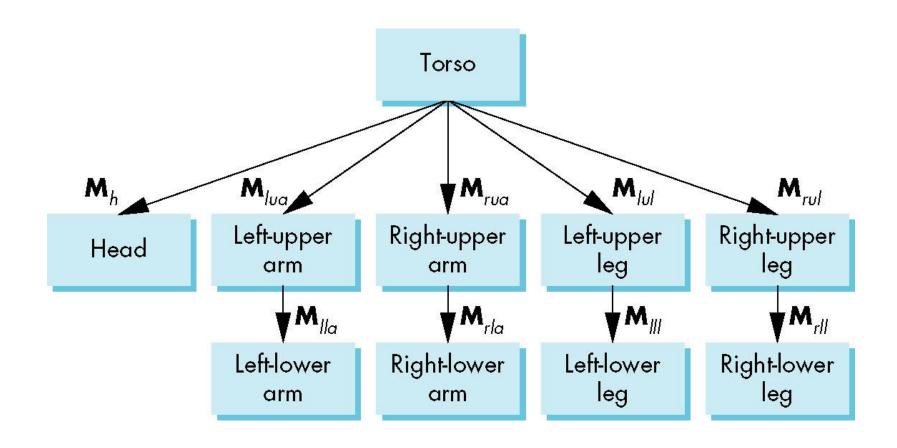
Humanoid Figure



Building the Model

- Can build a simple implementation using quadrics: ellipsoids and cylinders
- Access parts through functions
 - torso()
 - leftUpperArm()
- Matrices describe position of node with respect to its parent
 - ullet $\mathbf{M}_{\mathrm{lla}}$ positions left lower leg with respect to left upper arm

Tree with Matrices



Display and Traversal

- The position of the figure is determined by 11 joint angles (two for the head and one for each other part)
- Display of the tree requires a *graph traversal*
 - Visit each node once
 - Display function at each node that describes the part associated with the node, applying the correct transformation matrix for position and orientation

Transformation Matrices

- There are 10 relevant matrices
 - M positions and orients entire figure through the torso which is the root node
 - M_h positions head with respect to torso
 - \mathbf{M}_{lua} , \mathbf{M}_{rua} , \mathbf{M}_{lul} , \mathbf{M}_{rul} position arms and legs with respect to torso
 - \mathbf{M}_{lla} , \mathbf{M}_{rla} , \mathbf{M}_{rll} , \mathbf{M}_{rll} position lower parts of limbs with respect to corresponding upper limbs

Stack-based Traversal

- Set model-view matrix to M and draw torso
- Set model-view matrix to MM_h and draw head
- For left-upper arm need \mathbf{MM}_{lua} and so on
- Rather than recomputing \mathbf{MM}_{lua} from scratch or using an inverse matrix, we can use the matrix stack to store \mathbf{M} and other matrices as we traverse the tree

Traversal Code

```
figure() {
   PushMatrix() ← save present model-view matrix
   torso();
                      update model-view matrix for head
   Rotate (...)
   head();
                      recover original model-view matrix
   PopMatrix();
   PushMatrix();
save it again
   Translate(...);
                          update model-view matrix
   Rotate(...); •
                          for left upper arm
   left_upper arm();
                          recover and save original
   PopMatrix();
                          model-view matrix again
   PushMatrix();
                             rest of code
```

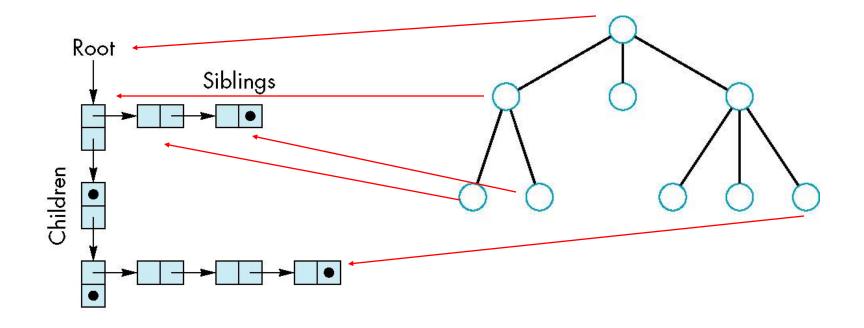
Analysis

- The code describes a particular tree and a particular traversal strategy
 - Can we develop a more general approach?
- Note that the sample code does not include state changes, such as changes to colors
 - May also want to push and pop other attributes to protect against unexpected state changes affecting later parts of the code

General Tree Data Structure

- Need a data structure to represent tree and an algorithm to traverse the tree
- We will use a <u>left-child right-sibling</u> structure
 - Uses linked lists
 - Each node in data structure is two pointers
 - Left: next node
 - Right: linked list of children

Left-Child Right-Sibling Tree



Tree Node Structure

- At each node we need to store
 - Pointer to sibling
 - Pointer to child
 - Pointer to a function that draws the object represented by the node
 - Homogeneous coordinate matrix to multiply on the right of the current modelview matrix
 - Represents changes going from parent to node
 - In WebGL this matrix is a 1D array storing matrix by columns

Creating a Tree Node

```
function createNode(transform, render, sibling, child)
    var node = {
        transform: transform,
        render: render,
        sibling: sibling,
        child: child,
    return node;
```

Initializing Nodes

```
function initNodes(Id) {
   var m = mat4();
    switch(Id) {
       case torsoId:
           m = rotate(theta[torsoId], 0, 1, 0);
           figure[torsoId] = createNode(m, torso, null, headId);
           break;
       case head1Id:
       case head2Id:
           m = translate(0.0, torsoHeight+0.5*headHeight, 0.0);
           m = mult(m, rotate(theta[head1Id], 1, 0, 0));
           m = mult(m, rotate(theta[head2Id], 0, 1, 0));
           m = mult(m, translate(0.0, -0.5*headHeight, 0.0));
           figure[headId] = createNode(m, head, leftUpperArmId, null);
           break;
```

Notes

- The position of figure is determined by 11 joint angles stored in theta[11]
- Animate by changing the angles and redisplaying
- We form the required matrices using rotate and translate
- Because the matrix is formed using the model-view matrix, we may want to first push original model-view matrix on matrix stack

Preorder Traversal

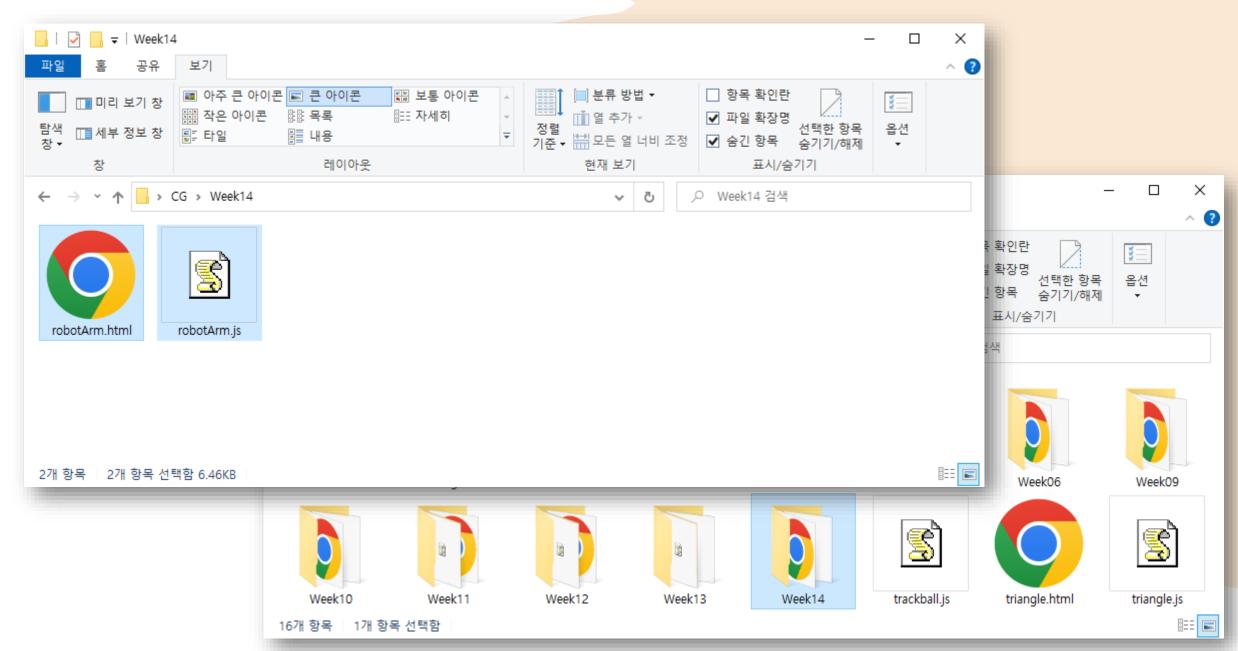
```
function traverse(Id) {
     if(Id == null) return;
     stack.push (modelViewMatrix);
     modelViewMatrix = mult(modelViewMatrix, figure[Id].transform);
     figure[Id].render();
     if(figure[Id].child != null) traverse(figure[Id].child);
     modelViewMatrix = stack.pop();
     if(figure[Id].sibling != null) traverse(figure[Id].sibling);
var render = function() {
    gl.clear( gl.COLOR_BUFFER_BIT );
    traverse(torsoId);
    requestAnimFrame(render);
```

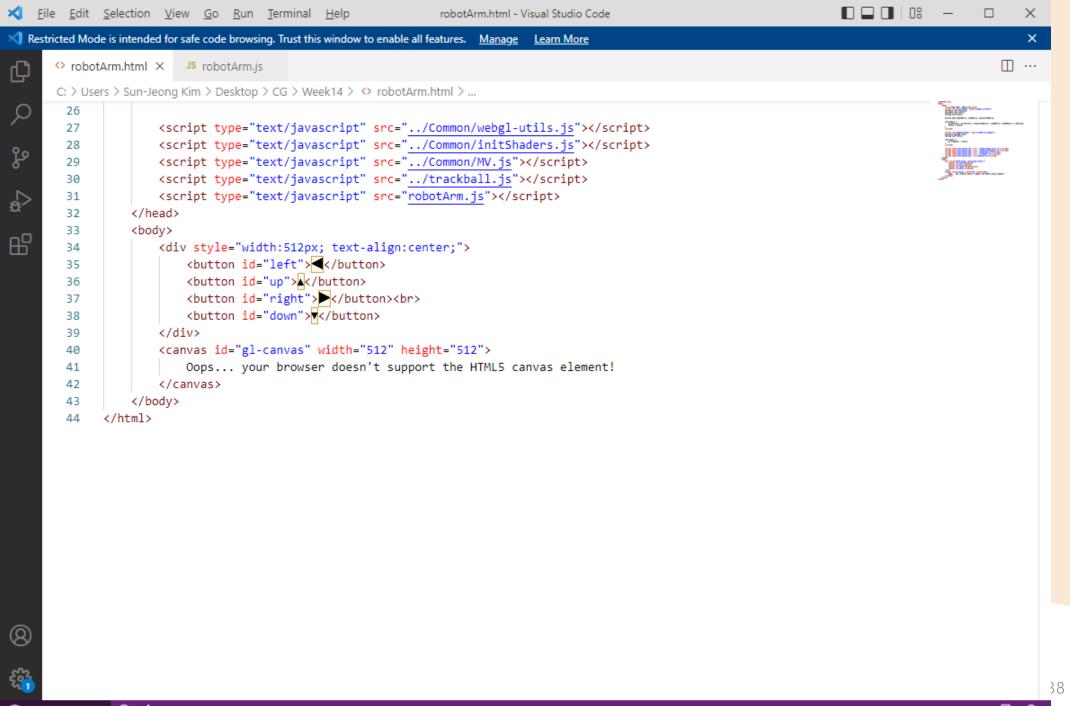
Notes

- We must save model-view matrix before multiplying it by node matrix
 - Updated matrix applies to children of node but not to siblings which contain their own matrices
- The traversal program applies to any left-child right-sibling tree
 - The particular tree is encoded in the definition of the individual nodes
- The order of traversal matters because of possible state changes in the functions

Dynamic Trees

- Because we are using JS, the nodes and the node structure can be changed during execution
- Definition of nodes and traversal are essentially the same as before but we can add and delete nodes during execution
- In desktop OpenGL, if we use pointers, the structure can be dynamic





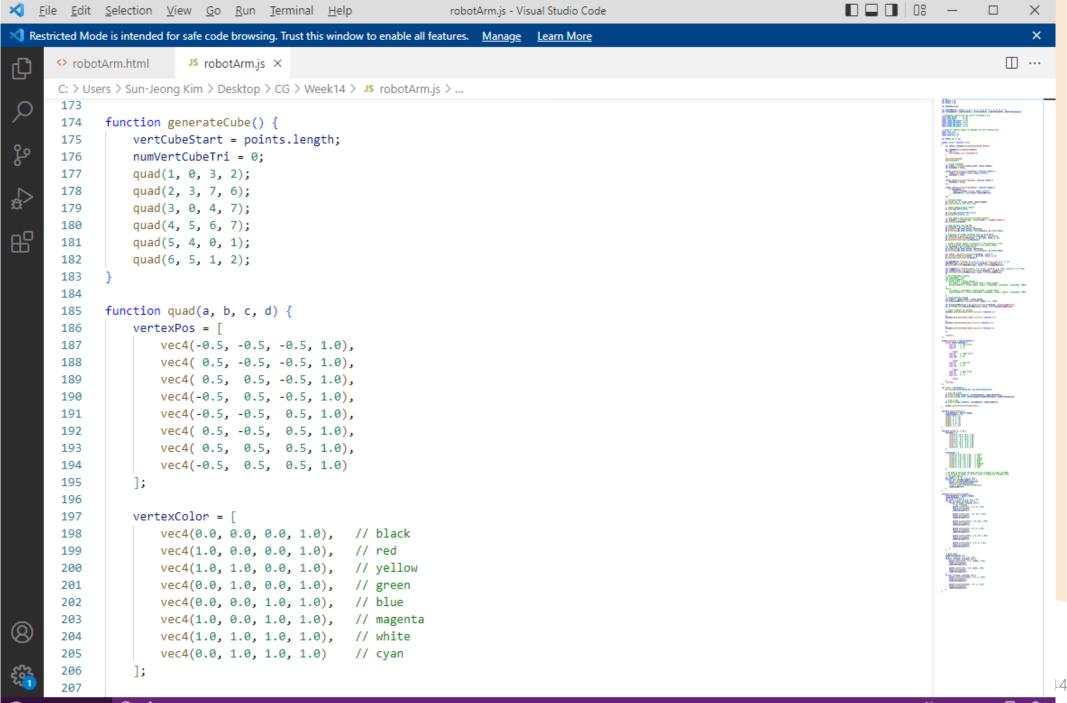
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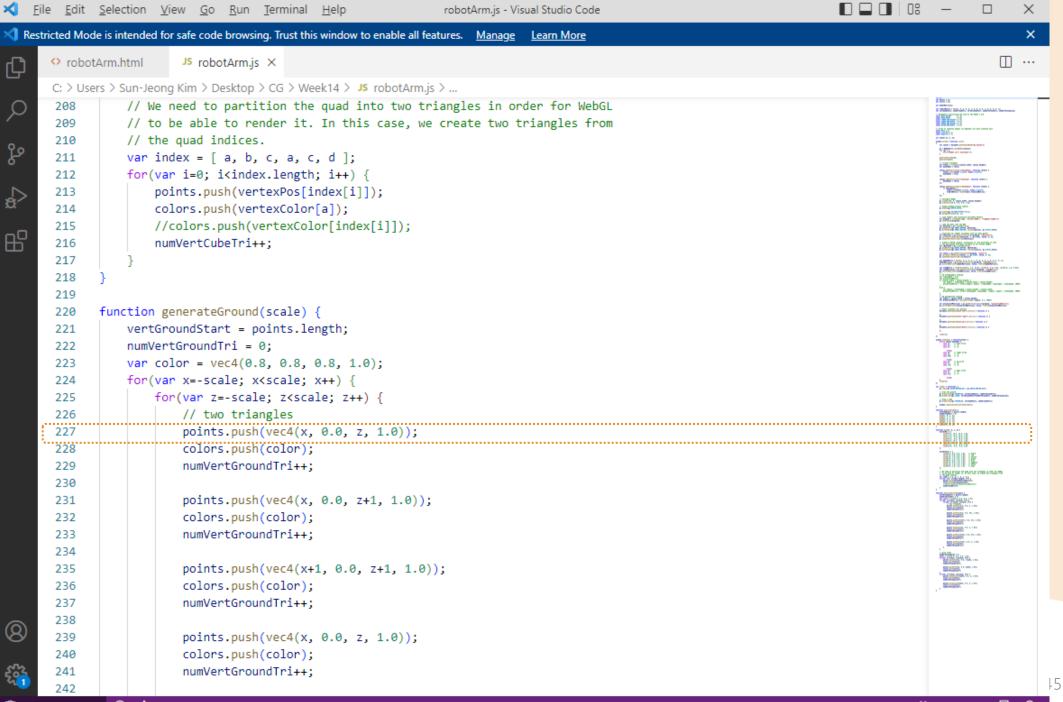
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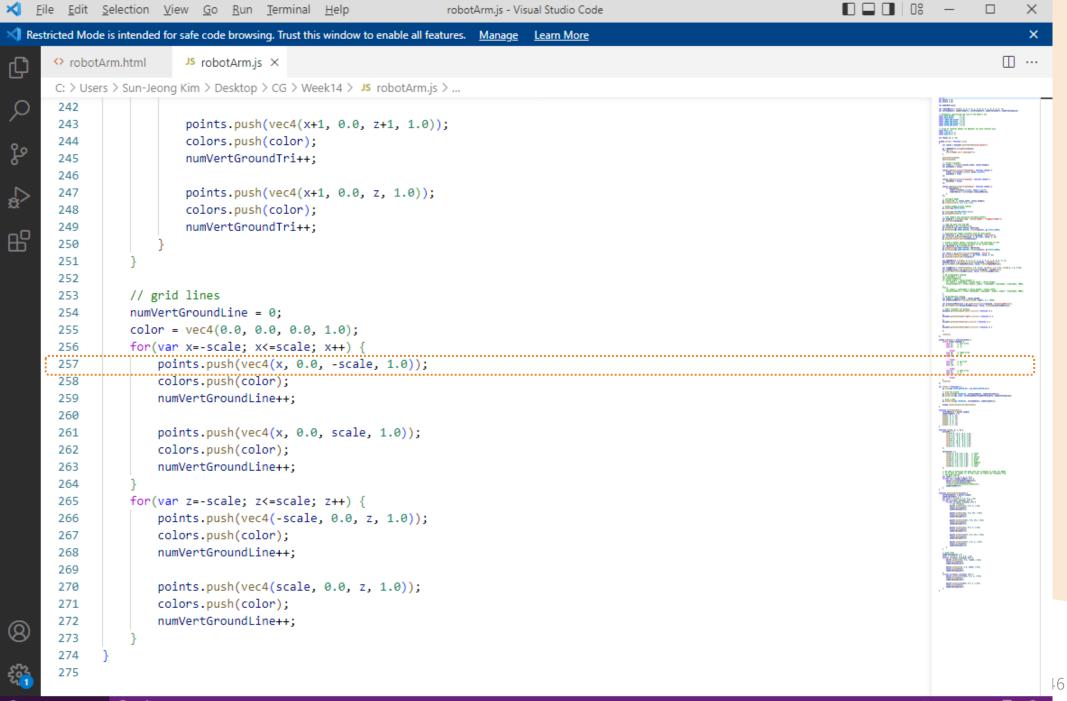
X File Edit Selection View Go Run Terminal Help robotArm.js - Visual Studio Code X × 刘 Restricted Mode is intended for safe code browsing. Trust this window to enable all features. <u>Manage Learn More</u> □ … > robotArm.html Js robotArm.js X C: > Users > Sun-Jeong Kim > Desktop > CG > Week14 > JS robotArm.js > ... 36 E DESCRIPTION AND A SAME AND A SA // virtual trackball 37 PARTIES AND ADDRESS OF THE PARTIES AND ADDRESS O var trball = trackball(canvas.width, canvas.height); 38 مع 39 var mouseDown = false; 100 PM No. of Lot, Lot, 40 Town to the last of the last o canvas.addEventListener("mousedown", function (event) { 41 Windows. A STATE OF THE PARTY OF THE PAR trball.start(event.clientX, event.clientY); 42 Maria and Control mouseDown = true; 43 MANAGE THE VEHICLE OF THE }); 44 The second second AND DESCRIPTION OF THE 45 PARTICIPATION AND PROPERTY. Ment and property. canvas.addEventListener("mouseup", function (event) { 46 WE WOLLD THE TANK mouseDown = false; AMERICAN STREET, STREE 47 MINERAL CO. A DESCRIPTION OF THE PERSON 48 }); harden and the same of 49 canvas.addEventListener("mousemove", function (event) { 1 50 E 17" if (mouseDown) { 51 1 1 Y HE IV trball.end(event.clientX, event.clientY); 52 53 trballMatrix = mat4(trball.rotationMatrix); The second section is 54 55 }); 56 // Configure WebGL 57 THE PERSON NAMED IN COLUMN gl.viewport(0, 0, canvas.width, canvas.height); 58 gl.clearColor(0.0, 0.0, 0.0, 1.0); 59 60 10 mm E-100 11 11 11 11 // Enable hidden-surface removal 11.1m 61 **B.** E-100 gl.enable(gl.DEPTH TEST); 62 THE STREET 63 E-100 MINER TV. gl.enable(gl.POLYGON_OFFSET_FILL); 64 10 mm gl.polygonOffset(0.01, 1); 65 66 // Load shaders and initialize attribute buffers 67 var program = initShaders(gl, "vertex-shader", "fragment-shader"); 68 gl.useProgram(program); 69 10 70

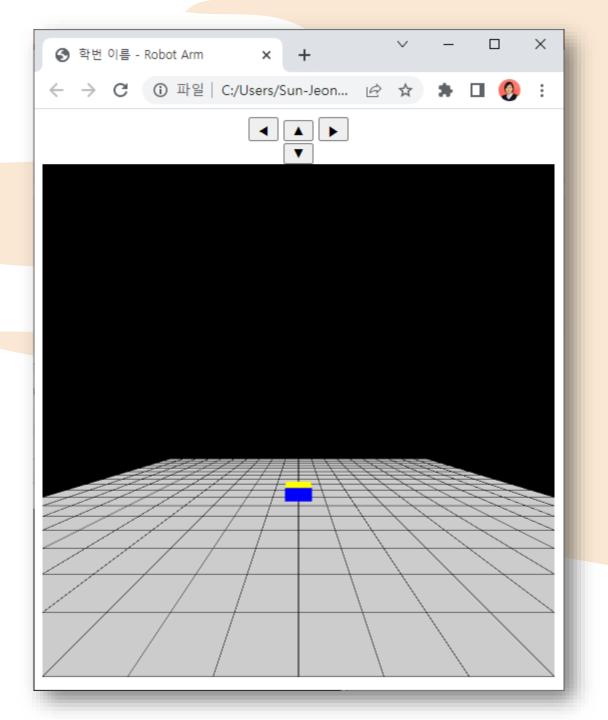
X File Edit Selection View Go Run Terminal Help robotArm.js - Visual Studio Code X × 刘 Restricted Mode is intended for safe code browsing. Trust this window to enable all features. <u>Manage Learn More</u> □ … > robotArm.html Js robotArm.js X C: > Users > Sun-Jeong Kim > Desktop > CG > Week14 > JS robotArm.js > ... else { 106 E DESCRIPTION AND A SAME AND A SA M. 107 var aspect = viewLength * canvas.height / canvas.width; Marine Wallet projectionMatrix = ortho(-viewLength, viewLength, -aspect, aspect, -viewLength, 1000); 108 PARTY OF THE PARTY OF T 109 BELLINGS OF THE REAL PROPERTY. */ No. of Lot, Lot, 110 Town to the last of the last o // 3D perspective viewing 111 Windows. A STATE OF THE PARTY OF THE PAR var aspect = canvas.width / canvas.height; 112 Maria and Control var projectionMatrix = perspective(90, aspect, 0.1, 1000); 113 12002200 man. PROVINCE SKIPS. 114 THE RESERVE OF THE PARTY OF THE var projectionMatrixLoc = gl.getUniformLocation(program, "projectionMatrix"); AND DESCRIPTION OF THE 115 MENTAL PROPERTY. gl.uniformMatrix4fv(projectionMatrixLoc, false, flatten(projectionMatrix)); 116 THE STATE OF THE S 117 AMERICAN STREET, STREE MINERAL CO. A DESCRIPTION OF THE BUILDING // Event listeners for buttons 118 ____ document.getElementById("left").onclick = function () { 119 120 1111 E 17" 121 }; E 1977 E 1777 document.getElementById("right").onclick = function () { 122 123 illi Errannani ra }; 124 document.getElementById("up").onclick = function () { 125 126 }; 127 THE PERSON NAMED IN COLUMN 128 document.getElementById("down").onclick = function () { 129 }; 130 10 July 14 P. LT. E-100 131 132 render(); The State of the last 133 EAST TO SELECT Mark Water 134 E100. window.onkeydown = function(event) { 135 switch (event.keyCode) { 136 137 // left arrow case 37: // 'A' case 65: 138 // 'a' 139 case 97: 1-2 140

X File Edit Selection View Go Run Terminal Help robotArm.js - Visual Studio Code 刘 Restricted Mode is intended for safe code browsing. Trust this window to enable all features. <u>Manage Learn More</u> □ … > robotArm.html JS robotArm.js X C: > Users > Sun-Jeong Kim > Desktop > CG > Week14 > J5 robotArm.js > ... 140 E DESCRIPTION AND A SAME AND A SA 141 break; PARTIES AND ADDRESS OF THE PARTIES AND ADDRESS O // right arrow 142 case 39: case 68: // 'D' 143 100 PM // 'd' case 100: 144 District of the last Total Villa Control of the last 145 Winnerson. A STATE OF THE PARTY OF THE PAR 146 break; Maria and Control 147 case 38: // up arrow 1200220 mm. PROVINCE SKIPS. // 'W' case 87: 148 THE RESERVE OF THE PARTY OF THE AND DESCRIPTION OF THE // 'w' 149 case 119: THE RESERVE OF THE PARTY OF THE 150 WENTER THE TANK AMERICAN STREET, STREE 151 break; MINERAL CO. A DESCRIPTION OF THE BUILDING 152 case 40: // down arrow ____ // '5' case 83: 153 // 's' 154 case 115: E 17" 155 E 1777 156 break; 157 illi Errannani ra 158 render(); 159 160 var render = function() { 161 Marie Policies College gl.clear(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT); 162 163 164 // draw the ground W-100 ----165 gl.drawArrays(gl.TRIANGLES, vertGroundStart, numVertGroundTri); gl.drawArrays(gl.LINES, vertGroundStart+numVertGroundTri, numVertGroundLine); 166 10 July 11 10 10 Mark Wash // draw a cube E-1000 168 gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri); 169 170 171 window.requestAnimationFrame(render); 172 173 function generateCube()

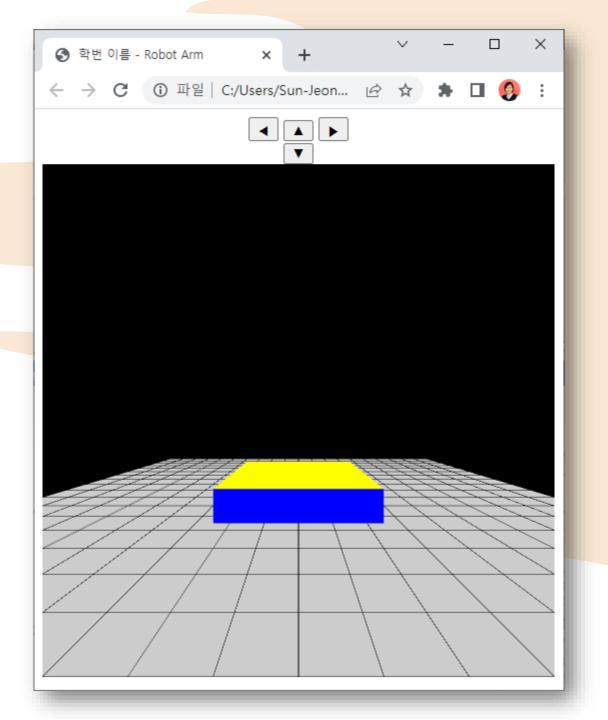


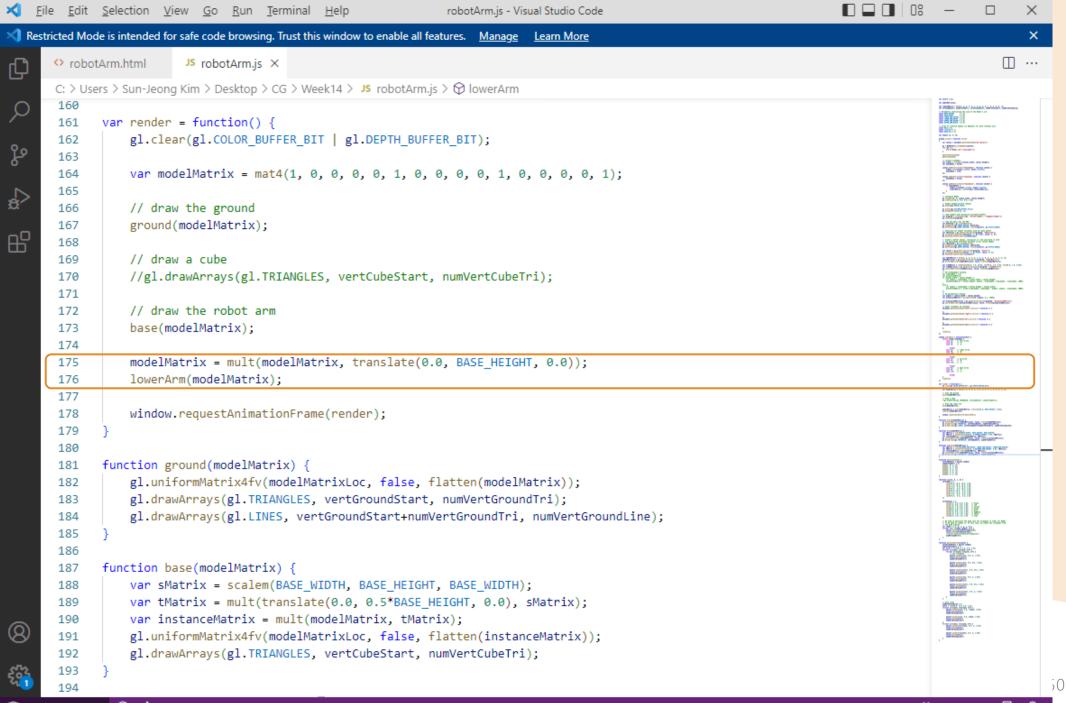




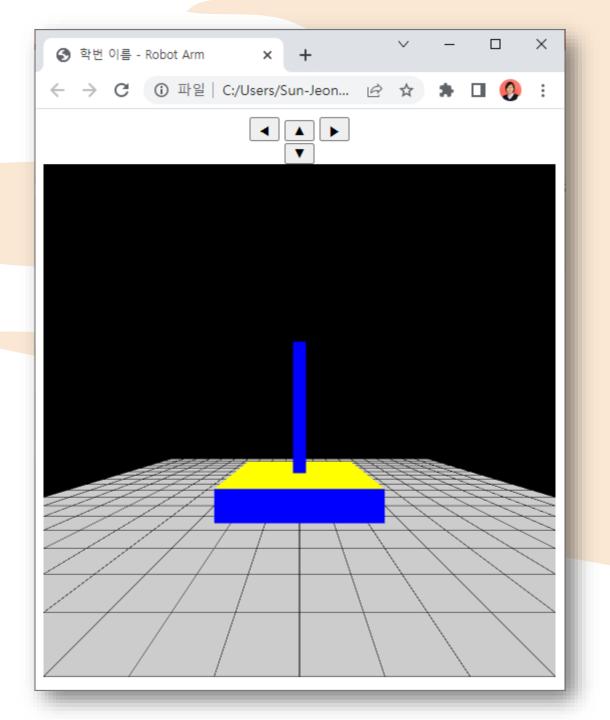


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                                                 var render = function() {
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                                                                gl.clear(gl.COLOR BUFFER BIT | gl.DEPTH BUFFER BIT);
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                                                                var modelMatrix = mat4(1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1);
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                                                                // draw the ground
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                                                                ground(modelMatrix);
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                                                                //gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri);
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                                                                // draw the robot arm
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                                                                base(modelMatrix);
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                                                  function ground(modelMatrix)
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                                                                gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(modelMatrix));
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                                                                gl.drawArrays(gl.TRIANGLES, vertGroundStart, numVertGroundTri);
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                                                                gl.drawArrays(gl.LINES, vertGroundStart+numVertGroundTri, numVertGroundLine);
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                                                  function base(modelMatrix) {
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        var sMatrix = scalem(BASE WIDTH, BASE_HEIGHT, BASE_WIDTH);
                           185
                                                                var tMatrix = mult(translate(0.0, 0.5*BASE HEIGHT, 0.0), sMatrix);
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                                                                var instanceMatrix = mult(modelMatrix, tMatrix);
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                                                                gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(instanceMatrix));
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                                                                gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri);
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                          192
                                                  function generateCube() {
                                                                vertCubeStart = points.length;
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                           194
                                                                numVertCubeTri = 0;
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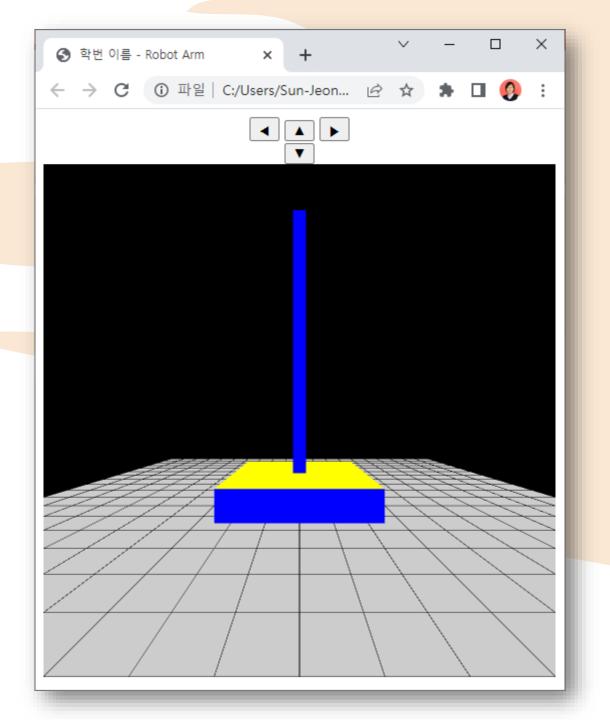


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                                                                                                               function ground(modelMatrix) {
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                                                                                                                                               gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(modelMatrix));
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                                                                                                                                               gl.drawArrays(gl.TRIANGLES, vertGroundStart, numVertGroundTri);
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                                                            184
                                                                                                                                              gl.drawArrays(gl.LINES, vertGroundStart+numVertGroundTri, numVertGroundLine);
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                                                                                                              function base(modelMatrix) {
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                                                                                                                                              var sMatrix = scalem(BASE WIDTH, BASE HEIGHT, BASE WIDTH);
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                                                                                                                                              var tMatrix = mult(translate(0.0, 0.5*BASE HEIGHT, 0.0), sMatrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                PARTICIPATION AND ADDRESS.
                                                            189
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                                                                                                                                              var instanceMatrix = mult(modelMatrix, tMatrix);
                                                            190
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                                                                                                                                              gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(instanceMatrix));
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                                                                                                                                               gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri);
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                                                                                                                function lowerArm(modelMatrix) {
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                                                                                                                                               var sMatrix = scalem(LOWER ARM WIDTH, LOWER ARM HEIGHT, LOWER ARM WIDTH);
                                                           196
                                                                                                                                              var tMatrix = mult(translate(0.0, 0.5*LOWER ARM HEIGHT, 0.0), sMatrix);
                                                           197
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                                                                                                                                              gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(instanceMatrix));
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                                                                                                                                               gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri);
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                                                                                                               function generateCube() {
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                                                                                                                                               vertCubeStart = points.length;
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                                                                                                                                               numVertCubeTri = 0;
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                                                                                                                                              quad(1, 0, 3, 2);
                                                            206
                                                            207
                                                                                                                                              quad(2, 3, 7, 6);
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                                                            208
                                                            209
                                                                                                                                              quad(4, 5, 6, 7);
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                                                                                                                                              quad(5, 4, 0, 1);
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                                                           211
                                                                                                                                              quad(6, 5, 1, 2);
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                                                                                                         function quad(a, b, c, d)
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                                                                                                                var render = function() {
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                                                                                                                                                    gl.clear(gl.COLOR BUFFER BIT | gl.DEPTH BUFFER BIT);
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                                                                                                                                                   var modelMatrix = mat4(1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1);
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                                                                                                                                                   //gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri);
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                                                                                                                                                   // draw the robot arm
                                                            172
                                                                                                                                                    base(modelMatrix);
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                                                                                                                                                   modelMatrix = mult(modelMatrix, translate(0.0, BASE HEIGHT, 0.0));
                                                            175
                                                                                                                                                   lowerArm(modelMatrix);
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                                                            177
                                                                                                                                                    modelMatrix = mult(modelMatrix, translate(0.0, LOWER ARM HEIGHT, 0.0));
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                                                                                                                  function ground(modelMatrix) {
                                                                                                                                                    gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(modelMatrix));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 The last services of the services
                                                            185
                                                                                                                                                   gl.drawArrays(gl.TRIANGLES, vertGroundStart, numVertGroundTri);
                                                            186
                                                                                                                                                    gl.drawArrays(gl.LINES, vertGroundStart+numVertGroundTri, numVertGroundLine);
                                                              187
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     E ....
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     E-100 ....
                                                              188
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    E---
                                                              189
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     10.100 · · · · · ·
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 WHEN SALES
                                                                                                                  function base(modelMatrix) {
                                                            190
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   ERE .....
   (8)
                                                            191
                                                                                                                                                    var sMatrix = scalem(BASE WIDTH, BASE HEIGHT, BASE WIDTH);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   Mark William
                                                                                                                                                   var tMatrix = mult(translate(0.0, 0.5*BASE HEIGHT, 0.0), sMatrix);
                                                              192
                                                                                                                                                   var instanceMatrix = mult(modelMatrix, tMatrix);
                                                              193
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 53
                                                                                                                                                   gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(instanceMatrix));
                                                              194
```

X File Edit Selection View Go Run Terminal Help X robotArm.js - Visual Studio Code × 刘 Restricted Mode is intended for safe code browsing. Trust this window to enable all features. <u>Manage Learn More</u> □ … > robotArm.html Js robotArm.js X C: > Users > Sun-Jeong Kim > Desktop > CG > Week14 > JS robotArm.js > ♦ upperArm 183 A STATE OF THE STATE OF T function ground(modelMatrix) { 184 gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(modelMatrix)); 185 مع gl.drawArrays(gl.TRIANGLES, vertGroundStart, numVertGroundTri); 186 Married World gl.drawArrays(gl.LINES, vertGroundStart+numVertGroundTri, numVertGroundLine); 187 William Book A CONTRACTOR OF THE PARTY OF TH 188 STATE OF THE PARTY 189 1907216 function base(modelMatrix) { PROVINCE SKIP. 190 var sMatrix = scalem(BASE_WIDTH, BASE_HEIGHT, BASE_WIDTH); 191 PRINCIPAL CONTRACTOR FREE TRANSPORTATION 192 var tMatrix = mult(translate(0.0, 0.5*BASE HEIGHT, 0.0), sMatrix); SECTION TO THE OWNER. var instanceMatrix = mult(modelMatrix, tMatrix); 193 ALEKSANIYAN SINGPLASIK TIDA SINA SINA SINA SINA MICHAEL CO. gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(instanceMatrix)); P. STORY OF THE PARTY OF THE PA 194 Name and Address of the Owner, where the gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri); 195 196 1111 III ITT 197 THE RES OF STREET function lowerArm(modelMatrix) { 198 199 var sMatrix = scalem(LOWER ARM WIDTH, LOWER ARM HEIGHT, LOWER ARM WIDTH); var tMatrix = mult(translate(0.0, 0.5*LOWER ARM HEIGHT, 0.0), sMatrix); 200 STATE OF THE PARTY var instanceMatrix = mult(modelMatrix, tMatrix); 201 THE RESIDENCE OF THE PARTY OF T gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(instanceMatrix)); 202 THE PROPERTY. The state of the s 203 gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri); Tell thousands 204 205 function upperArm(modelMatrix) { 206 var sMatrix = scalem(UPPER ARM WIDTH, UPPER ARM HEIGHT, UPPER ARM WIDTH); 207 var tMatrix = mult(translate(0.0, 0.5*UPPER_ARM HEIGHT, 0.0), sMatrix); 208 var instanceMatrix = mult(modelMatrix, tMatrix); 209 gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(instanceMatrix)); 210 ELECTRICAL PROPERTY. SELECTION OF THE REAL PROPERTY. gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri); 211 E. ... SELECTION OF THE REAL PROPERTY. 212 ELECTRICAL PROPERTY. WHEN YOU 213 E-100 (8) function generateCube() { Mark William 214 215 vertCubeStart = points.length; numVertCubeTri = 0; 216 217 quad(1, 0, 3, 2);

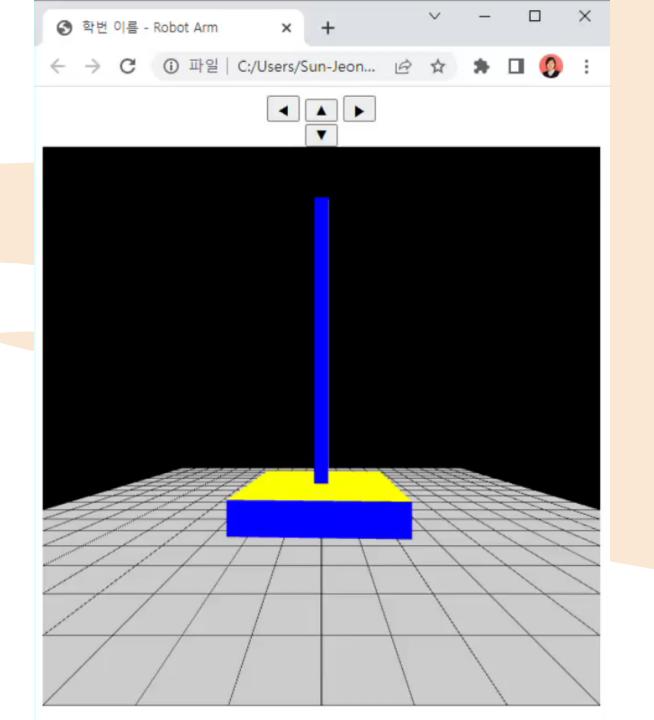


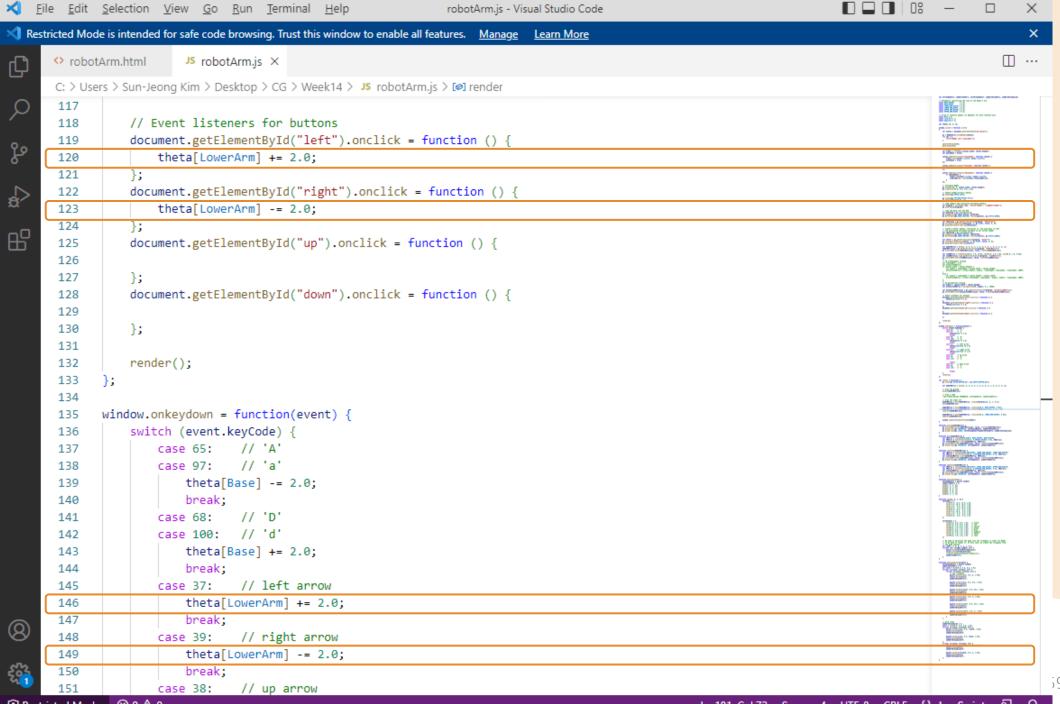
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X File Edit Selection View Go Run Terminal Help
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               robotArm.js - Visual Studio Code
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        X
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  Restricted Mode is intended for safe code browsing. Trust this window to enable all features. Manage Learn More
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    □ …
                                                                                                                                                                                                                                                                                                                                                                                                                 JS robotArm.js X
                                                                                                          > robotArm.html
                                                                                                               C: > Users > Sun-Jeong Kim > Desktop > CG > Week14 > JS robotArm.js > [●] render
                                                                                                                                                                                                                       window.onkeydown = function(event) {
                                                                                                                   135
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     Milita
                                                                                                                   136
                                                                                                                                                                                                                                                                                       switch (event.keyCode) {
                                                                                                            137
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              // 'A'
                                                                                                                                                                                                                                                                                                                                                             case 65:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                FREE PROPERTY.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                // 'a'
                                                                                                                 138
                                                                                                                                                                                                                                                                                                                                                        case 97:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  The same of the last
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  The same of the sa
                                                                                                                     139
                                                                                                                                                                                                                                                                                                                                                                                                                   theta[Base] -= 2.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    The same name of
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           A STATE OF THE PARTY OF THE PAR
                                                                                                                   140
                                                                                                                                                                                                                                                                                                                                                                                                                      break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           STATE OF THE PARTY OF THE PARTY
                                                                                                                                                                                                                                                                                                                                                        case 68:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     // 'D'
                                                                                                                   141
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                1200 Page 100 Page 10
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                THE PERSON NAMED IN
                                                                                                                                                                                                                                                                                                                                                      case 100: // 'd'
                                                                                                                     142
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           THE RESERVE OF
                                                                                                                   143
                                                                                                                                                                                                                                                                                                                                                                                                                   theta[Base] += 2.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                STATE OF THE REAL PROPERTY.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                PREMISE AND PROPERTY.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                A STATE OF THE PARTY OF THE PAR
                                                                                                                     144
                                                                                                                                                                                                                                                                                                                                                                                                                      break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           case 37:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     // left arrow
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AND ADDRESS OF THE PARTY OF THE
                                                                                                                     145
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           MICHAEL CO.
                                                                                                                   146
                                                                                                                                                                                                                                                                                                                                                                                                                      break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AND DESCRIPTION OF THE PERSON NAMED IN
                                                                                                                   147
                                                                                                                                                                                                                                                                                                                                                             case 39:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  // right arrow
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       THE REAL PROPERTY.
                                                                                                                 148
                                                                                                                                                                                                                                                                                                                                                                                                                   break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  case 38:
                                                                                                                   149
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     // up arrow
                                                                                                                   150
                                                                                                                                                                                                                                                                                                                                                        case 87:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       // 'W'
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    100
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            // 'w'
                                                                                                                   151
                                                                                                                                                                                                                                                                                                                                                        case 119:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                USUA was read to the
                                                                                                                   152
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                MARK ...
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         STATE OF THE PARTY OF THE PARTY
                                                                                                                   153
                                                                                                                                                                                                                                                                                                                                                                                                                      break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         THE RESIDENCE OF THE PARTY OF T
                                                                                                                   154
                                                                                                                                                                                                                                                                                                                                                        case 40:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     // down arrow
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           THE PERSON NAMED IN
                                                                                                                   155
                                                                                                                                                                                                                                                                                                                                                        case 83:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     // '5'
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           Tell the pass of the
                                                                                                                                                                                                                                                                                                                                                      case 115: // 's'
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         The state of the s
                                                                                                                   156
                                                                                                                   157
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                                                                                                                                                                                                                                                                                                                                                                                                                      break;
                                                                                                                     159
                                                                                                                                                                                                                                                                                       render();
                                                                                                                   160
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                TOTAL PROPERTY.
                                                                                                                   161
                                                                                                                                                                                                                     };
                                                                                                                   162
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         E-100 ** ** **
                                                                                                                                                                                                                       var render = function() {
                                                                                                                   163
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         10 July 11 L 15
                                                                                                                                                                                                                                                                                         gl.clear(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT);
                                                                                                                   164
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         $5,500 mm.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                THE HALL
                                                                                                                   165
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                10.000 · · · · ·
                                                                                                                                                                                                                                                                                       var modelMatrix = mat4(1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1);
                                                                                                                     166
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  Market Co.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  SECTION AND ADDRESS OF THE PERSON NAMED IN
                                                                                                                   167
                                                                                                                                                                                                                                                                                       // draw the ground
                                                                                                                     168
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                56
                                                                                                                                                                                                                                                                                    ground(modelMatrix);
                                                                                                                     169
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X File Edit Selection View Go Run Terminal Help
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      robotArm.js - Visual Studio Code
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  ×
   刘 Restricted Mode is intended for safe code browsing. Trust this window to enable all features. <u>Manage Learn More</u>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    □ …
                                                                               > robotArm.html
                                                                                                                                                                                                                                                                                                        Js robotArm.js X
                                                                                  C: > Users > Sun-Jeong Kim > Desktop > CG > Week14 > Js robotArm.js > [@] render
                                                                                    162
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         THE PERSON NAMED IN COLUMN TO SECURE A SECURE ASSESSMENT OF SECURE ASSES
                                                                                                                                                               var render = function() {
                                                                                      163
                                                                                                                                                                                                             gl.clear(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT);
                                                                                      164
      وع
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                Married Street, Square,
                                                                                      165
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       William Book
                                                                                                                                                                                                          var modelMatrix = mat4(1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1);
                                                                                    166
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                - Commonweal
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              STATE OF THE PARTY OF THE PARTY
                                                                                    167
                                                                                                                                                                                                            // draw the ground
                                                                                      168
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   1207216 mar.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   MANAGES SACRE.
                                                                                                                                                                                                            ground(modelMatrix);
                                                                                      169
                                                                                    170
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     PRINCIPAL CONTRACTOR
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     FREE TARREST STREET,
                                                                                                                                                                                                             // draw a cube
                                                                                    171
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     WEGGEN THE THE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     Authorite Control of the Control of 
                                                                                      172
                                                                                                                                                                                                            //gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     MODERN CO.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     A DESCRIPTION OF THE PERSON.
                                                                                    173
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     Name and Address of the Owner, where the
                                                                                                                                                                                                            // draw the robot arm
                                                                                    174
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          TT.
                                                                                    175
                                                                                                                                                                                                             modelMatrix = mult(modelMatrix, rotate(theta[Base], 0, 1, 0 ));
                                                                                                                                                                                                             base(modelMatrix);
                                                                                    176
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if it
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                                                                                    177
                                                                                                                                                                                                             modelMatrix = mult(modelMatrix, translate(0.0, BASE HEIGHT, 0.0));
                                                                                    178
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   ARREST CO.
                                                                                                                                                                                                            lowerArm(modelMatrix);
                                                                                      179
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              100 Lane 100
                                                                                      180
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                THE RESIDENCE OF THE PERSON NAMED IN
                                                                                                                                                                                                             modelMatrix = mult(modelMatrix, translate(0.0, LOWER ARM HEIGHT, 0.0));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   THE PARTY OF THE P
                                                                                      181
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   The state of the s
                                                                                                                                                                                                            upperArm(modelMatrix);
                                                                                      182
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                The same of the sa
                                                                                      183
                                                                                      184
                                                                                                                                                                                                             window.requestAnimationFrame(render);
                                                                                      185
                                                                                      186
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     Till E
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  The section of the se
                                                                                                                                                               function ground(modelMatrix) {
                                                                                    187
                                                                                                                                                                                                             gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(modelMatrix));
                                                                                      188
                                                                                    189
                                                                                                                                                                                                            gl.drawArrays(gl.TRIANGLES, vertGroundStart, numVertGroundTri);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        10 and 10
                                                                                                                                                                                                            gl.drawArrays(gl.LINES, vertGroundStart+numVertGroundTri, numVertGroundLine);
                                                                                      190
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        10.1.1m
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                                                                                    191
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   WHEN ST.
                                                                                      192
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     10 mm. in.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   MILENTY...
                                                                                                                                                             function base(modelMatrix) {
                                                                                      193
                                                                                                                                                                                                             var sMatrix = scalem(BASE_WIDTH, BASE_HEIGHT, BASE_WIDTH);
                                                                                      194
                                                                                                                                                                                                            var tMatrix = mult(translate(0.0, 0.5*BASE HEIGHT, 0.0), sMatrix);
                                                                                      195
                                                                                                                                                                                                          var instanceMatrix = mult(modelMatrix, tMatrix);

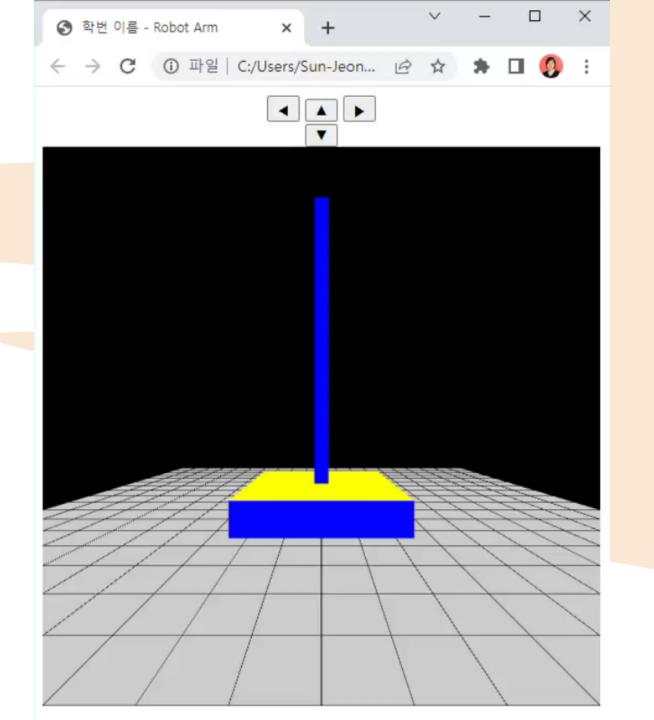
    Restricted Mode ⊗ 0 △ 0

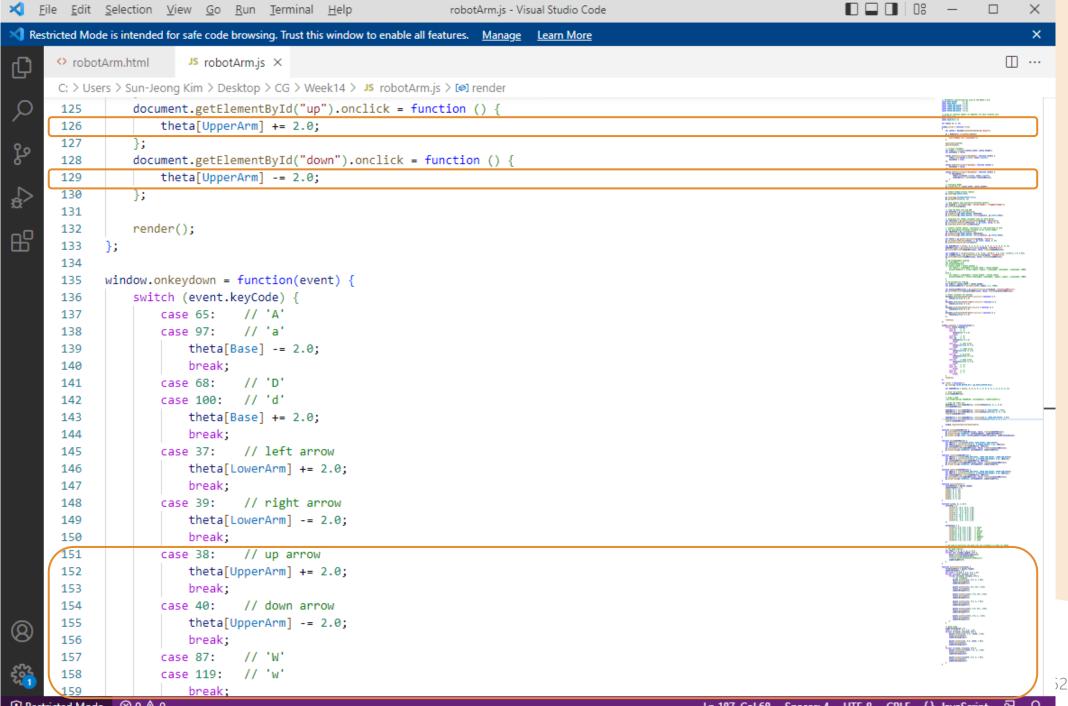
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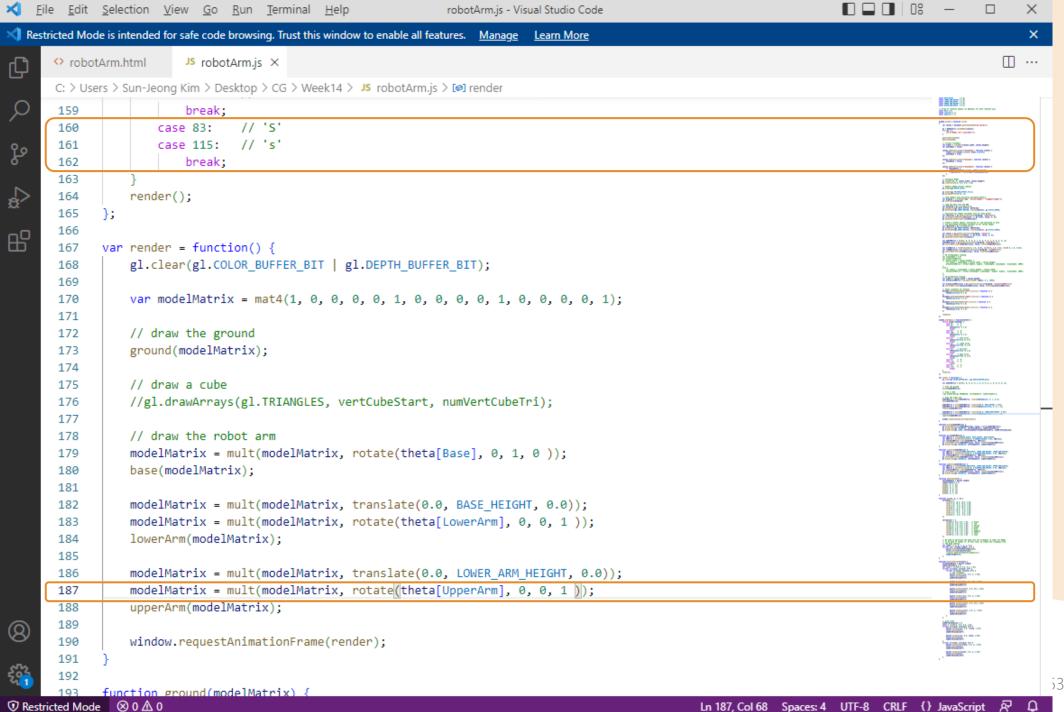


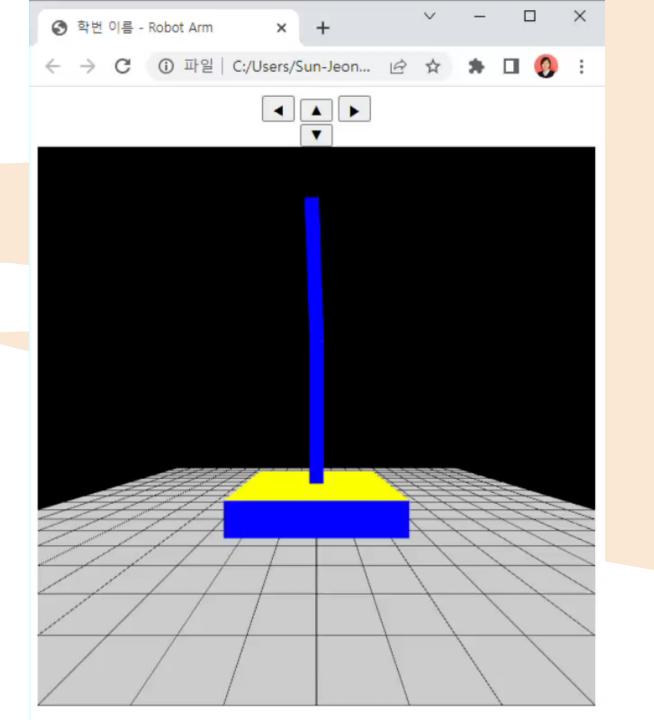


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X File Edit Selection View Go Run Terminal Help
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                X
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              robotArm.js - Visual Studio Code
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       ×
   刘 Restricted Mode is intended for safe code browsing. Trust this window to enable all features. <u>Manage Learn More</u>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       □ …
                                                                                  > robotArm.html
                                                                                                                                                                                                                                                                                                                  Js robotArm.js X
                                                                                     C: > Users > Sun-Jeong Kim > Desktop > CG > Week14 > Js robotArm.js > [@] render
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 164
                                                                                                                                                                  var render = function() {
                                                                                       165
                                                                                                                                                                                                                    gl.clear(gl.COLOR_BUFFER_BIT | gl.DEPTH_BUFFER_BIT);
                                                                                        166
      وع
                                                                                       167
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    Total St.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      William Book
                                                                                                                                                                                                                var modelMatrix = mat4(1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1);
                                                                                        168
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    A STATE OF THE PARTY OF THE PAR
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 STATE OF THE PARTY OF THE PARTY
                                                                                        169
                                                                                                                                                                                                                  // draw the ground
                                                                                        170
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    1207210 .....
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                                                                                                                                                                                                                  ground(modelMatrix);
                                                                                        171
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Children, parts
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 PARTICIPATION AND THE PARTY OF 
                                                                                       172
                                                                                                                                                                                                                    // draw a cube
                                                                                        173
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  PROPERTY OF STREET
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AND STREET STREET, STR
                                                                                                                                                                                                                  //gl.drawArrays(gl.TRIANGLES, vertCubeStart, numVertCubeTri);
                                                                                       174
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    MATERIAL STREET, STREE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Property of the same of the sa
                                                                                       175
                                                                                                                                                                                                                    // draw the robot arm
                                                                                       176
                                                                                                                                                                                                                    modelMatrix = mult(modelMatrix, rotate(theta[Base], 0, 1, 0 ));
                                                                                       177
                                                                                                                                                                                                                  base(modelMatrix);
                                                                                        178
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 HE IY
                                                                                       179
                                                                                                                                                                                                                    modelMatrix = mult(modelMatrix, translate(0.0, BASE_HEIGHT, 0.0));
                                                                                        180
                                                                                                                                                                                                                    modelMatrix = mult(modelMatrix, rotate(theta[LowerArm], 0, 0, 1 ));
                                                                                       181
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AND DESCRIPTION OF THE PARTY OF
                                                                                        182
                                                                                                                                                                                                                    lowerArm(modelMatrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               THE PERSON NAMED IN
                                                                                        183
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    THE TRANSPORT
                                                                                                                                                                                                                    modelMatrix = mult(modelMatrix, translate(0.0, LOWER ARM HEIGHT, 0.0));
                                                                                        184
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 Tell the pass of the
                                                                                                                                                                                                                  upperArm(modelMatrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 Tell thousand
                                                                                        185
                                                                                       186
                                                                                                                                                                                                                  window.requestAnimationFrame(render);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    187
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                                                                                                                                                                    function ground(modelMatrix) {
                                                                                        190
                                                                                                                                                                                                                    gl.uniformMatrix4fv(modelMatrixLoc, false, flatten(modelMatrix));
                                                                                       191
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           E100 ". r. in
                                                                                                                                                                                                                  gl.drawArrays(gl.TRIANGLES, vertGroundStart, numVertGroundTri);
                                                                                        192
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           STATE OF THE PARTY OF THE PARTY
                                                                                                                                                                                                                    gl.drawArrays(gl.LINES, vertGroundStart+numVertGroundTri, numVertGroundLine);
                                                                                        193
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           $5,500 mm.
                                                                                        194
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     (8)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      12.000 · · · · ·
                                                                                       195
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                                                                                                                                                                  function base(modelMatrix) {
                                                                                       196
                                                                                                                                                                                                                    var sMatrix = scalem(BASE WIDTH, BASE HEIGHT, BASE WIDTH);
                                                                                        197
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           50
                                                                                                                                                                                                                  var tMatrix = mult(translate(0.0, 0.5*BASE HEIGHT, 0.0), sMatrix);
```









연습 문제

- ADSW 키를 이용하여 Base를 전후좌우로 이동(translation) 시키시오.
- Base의 회전은 PageUp(33), PageDown(34)키를 이용하시오.