University Of Massachusetts, Lowell

Final Project Report

COMPUTER GRAPHICS

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Introduction

This project uses HTML,CSS, Javascript and WebGL with Three.js. I have also used Bootstrap for webpage designing. The main objective of this project is to model and transform 3D objects ,allow it to be viewed from multiple views and also provide other features like lighting, camera, shadows and animations to the object.

Implementation

This project is composed of 6 parts in total. Each part refers to the progress made over the course of 6 weeks on weekly-basis. I have created an index page for the project which directs to each of the six parts implemented. All the features are explained below in detail:

Technologies Used: HTML, CSS, Javascript, Bootstrap, WebGL, Three.js

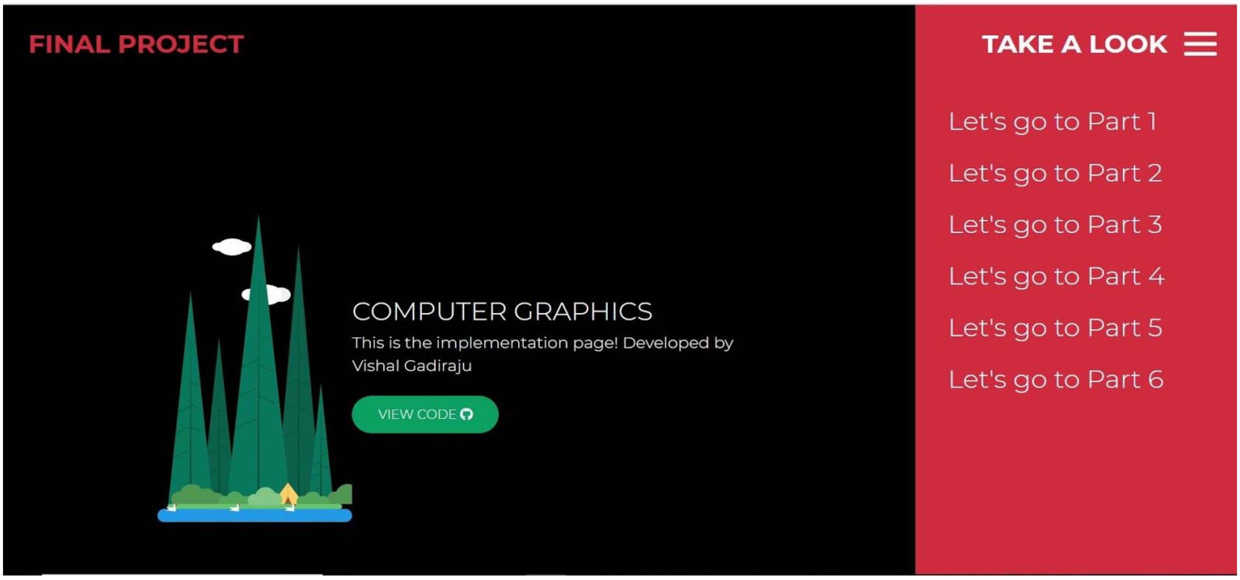
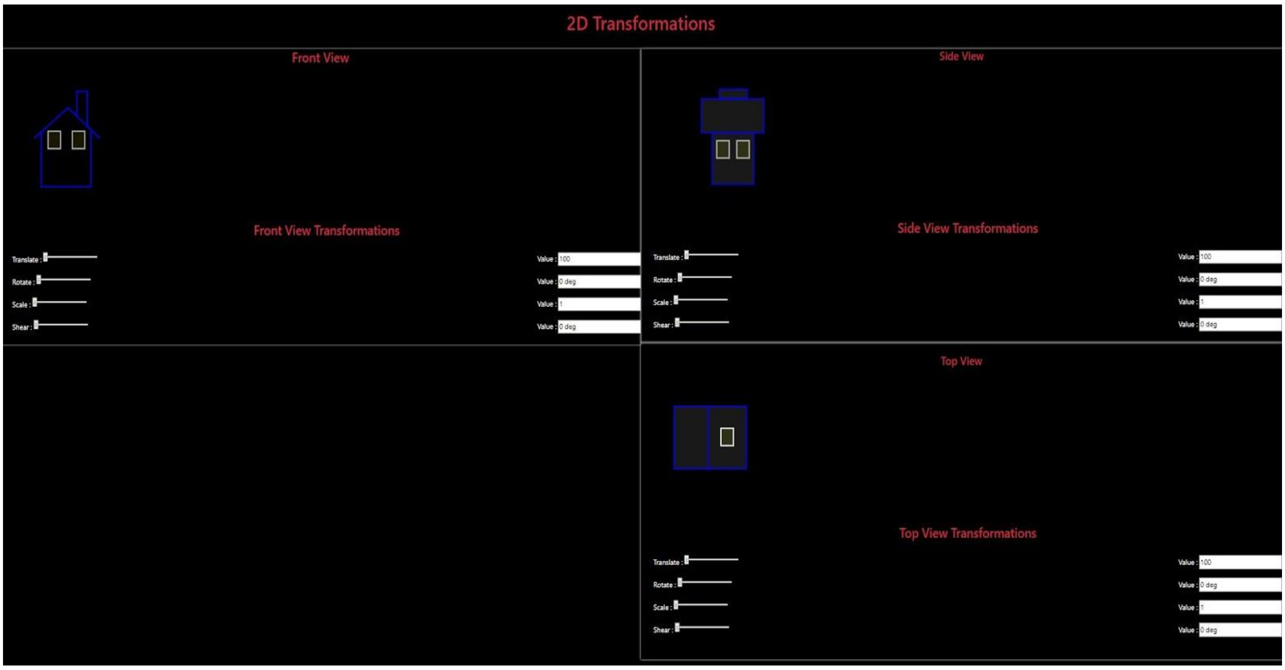


Fig1: Index Page with a menu directing to all 6 parts of the project and a link to Github repo.

Week 1 - Creation of 2D Object with Transformations and Views

- Created a 2D object i.e house using SVG
- Provided elevations on Front, Top and Side Views
- Implemented the following 2D transformations for each view:
  1. Translation
  2. Rotation
  3. Scaling
  4. Shear
- It also allows coordinates to be stored for further implementation.



Front View Transformations

Translate : Value : 100

Rotate : Value : 0 deg

Scale : Value : 1

Shear : Value : 0 deg

Side View Transformations

Translate : Value : 100

Rotate : Value : 0 deg

Scale : Value : 1

Shear : Value : 0 deg

Top View Transformations

Translate : Value : 100

Rotate : Value : 0 deg

Scale : Value : 1

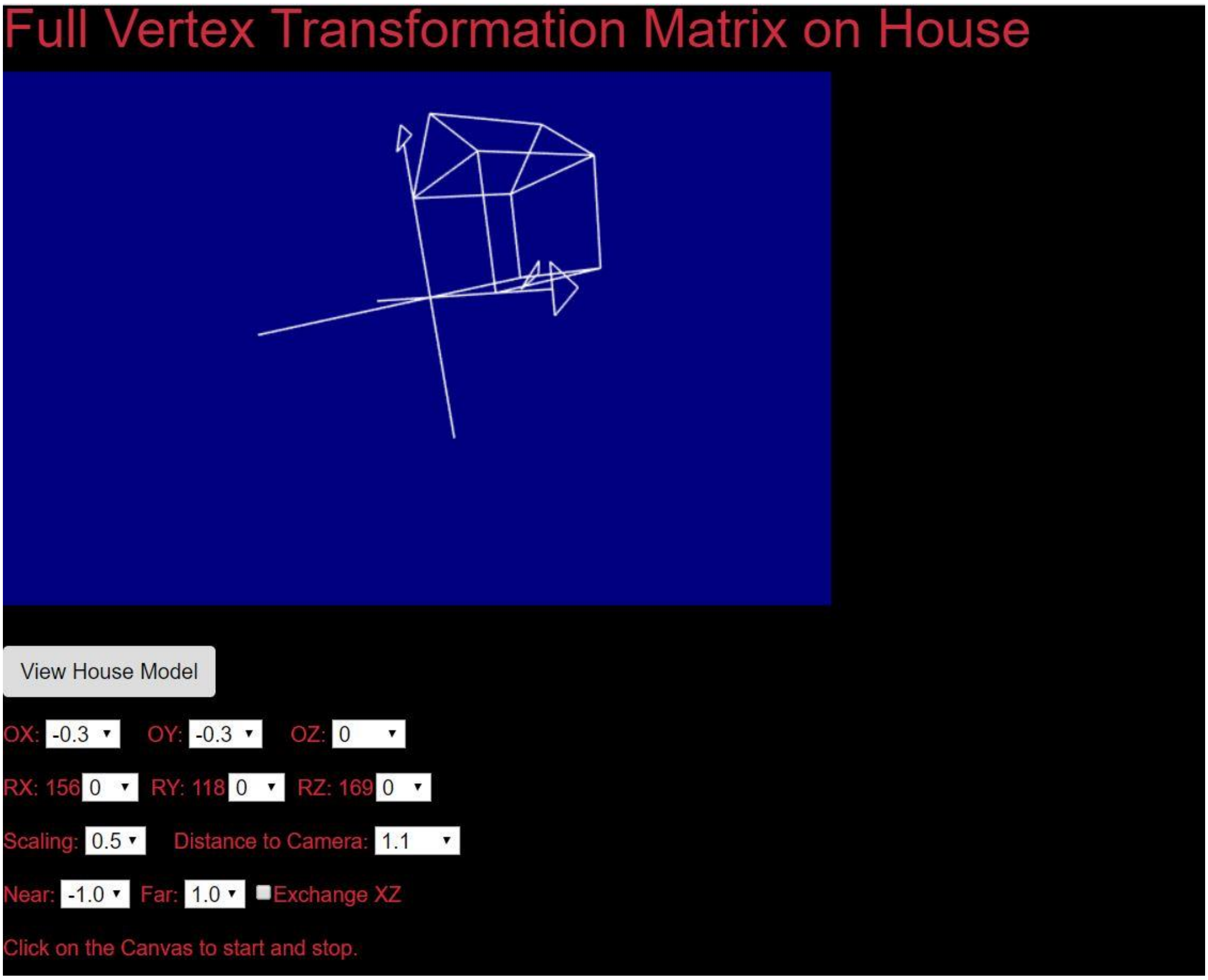
Shear : Value : 0 deg

Fig2: Part 1 of Project showing 2D transformations for House in 3 different views

Week 2 - Applying 3D Transformations, other features to the Object

- Created a 3D object i.e House
- Implemented 3D transformations combined by storing in the form of a matrix
- The list of features demonstrated are given as follows:
    1. Translation
    2. Rotation
    3. Scaling and Aspect Ratio
    4. Allows the object to be viewed from multiple views

- Other features include:
    1. Perspective Projection (One Point, Two Point, Three Point)
    2. Distance to Camera
    3. Near and Far
    4. Exchanging X and Z Coordinates to display Perspective Projection without any other transformations
- Model is interactive and allows user to try different combinations and view the static result by clicking on the canvas.



Full Vertex Transformation Matrix on House

OX: -0.3 ▾ OY: -0.3 ▾ OZ: 0 ▾

RX: 156 0 ▾ RY: 118 0 ▾ RZ: 169 0 ▾

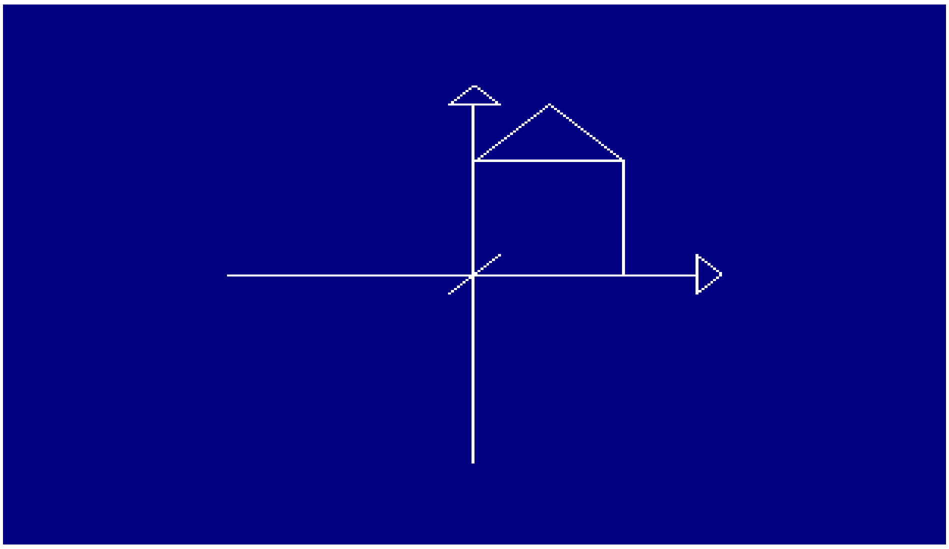
Scaling: 0.5 ▾ Distance to Camera: 1.1 ▾

Near: -1.0 ▾ Far: 1.0 ▾ □ Exchange XZ

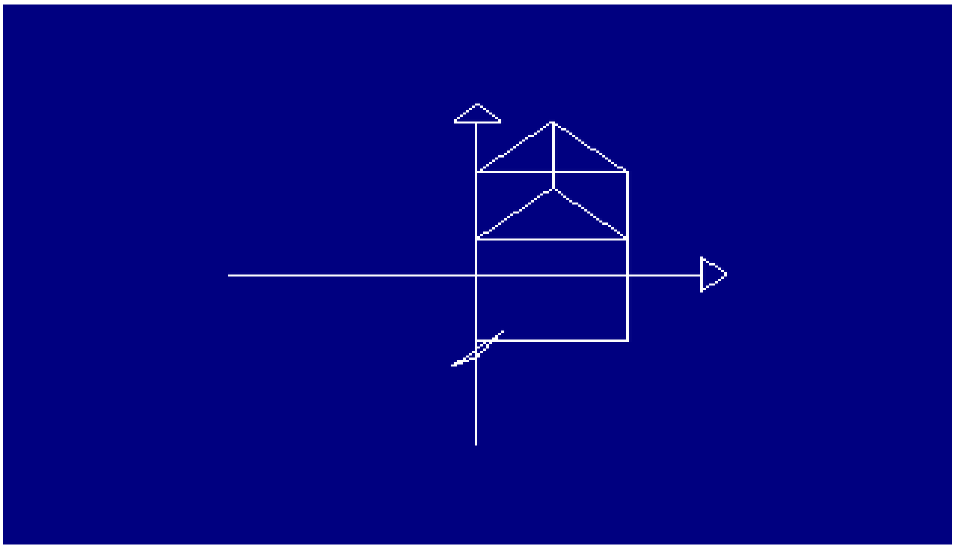
Click on the Canvas to start and stop.

Fig3: Part 2 of the project showing 3D transformations for House

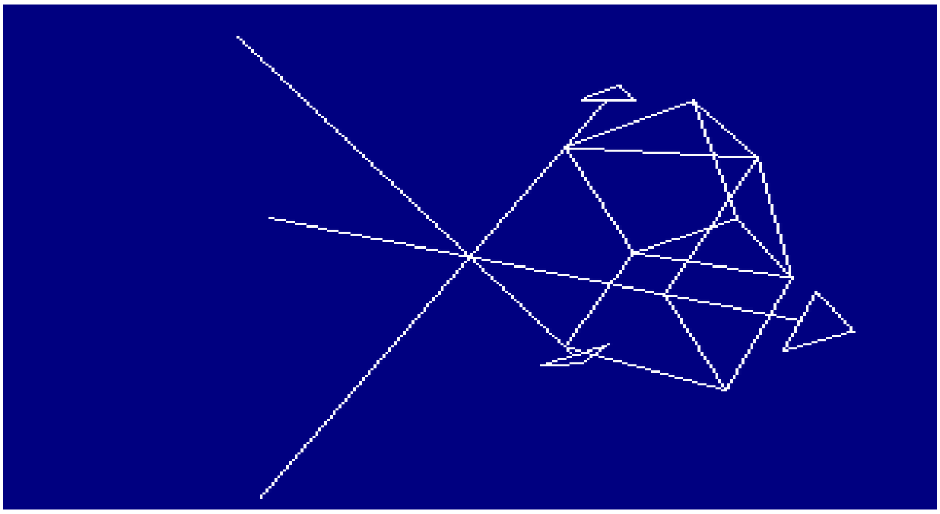
- The controls give the ability to decompose the full transformation step-by-step, i.e. we start with the following view:



After the rotation around the X axis:

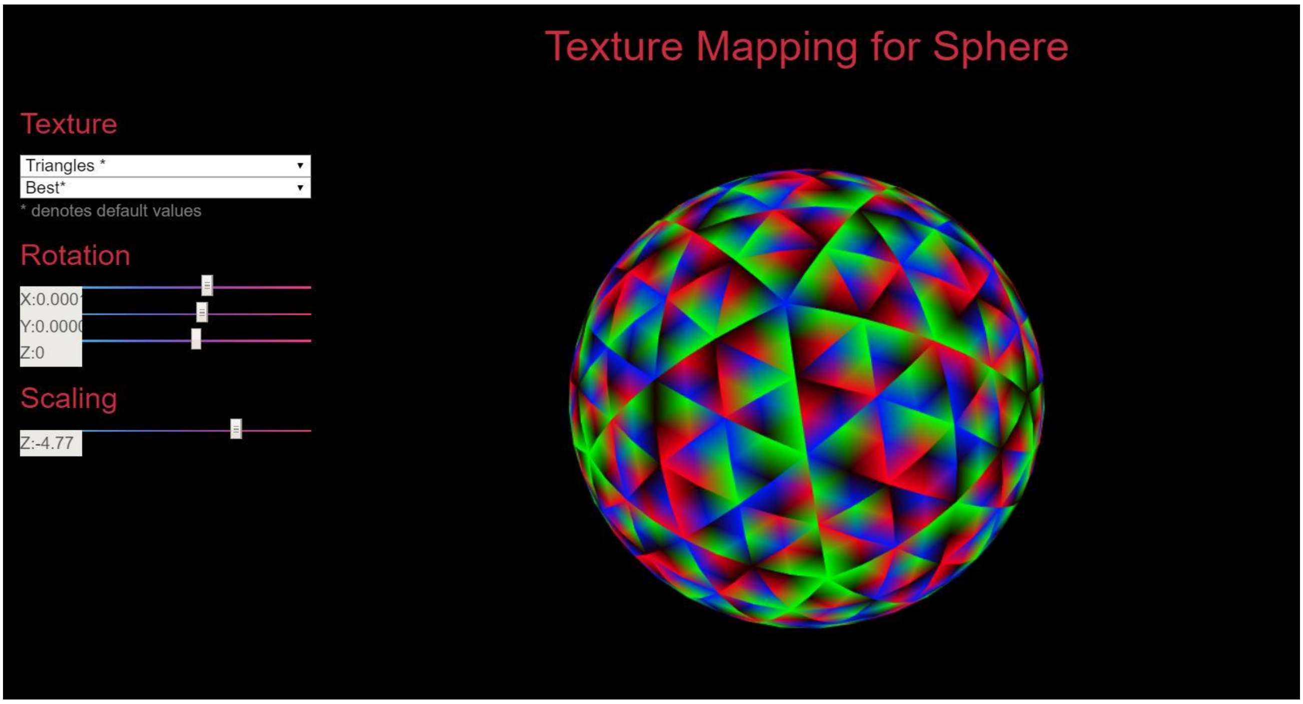


After perspective projection:



Week 3 - Creation of 3D object with Texture Mapping

- Created a new 3D Object i.e Sphere
- This part mainly uses HTML Canvas and Javascript and CSS
- For styling the Controls i have used a CSS gradient
- Implemented features such as:
    1. **Texture Mapping**
    2. **Rotation on X,Y,Z Coordinates**
    3. **Scaling**
- Additional Features include varied quality and varieties of textures to choose from.
- The model is interactive, meaning provides user an ability to play with different combinations



Triangles *
Best*
* denotes default values

X:0.000
Y:0.0000
Z:0

Z:-4.77

Fig4: Part 3 of the project showing 3D object, Sphere with Texture, Rotation and Scaling

Week 4 - Creation of More Objects with Texture Mapping, Shadows and Lighting

- Extending from the previous week's work, in this part **Texture Mapping** is shown for the object "House".
- The demo is completely interactive and allows the user to choose features such as:
    1. Wall Color
    2. Roof Design
    3. Front Color
- Provided various options for each of the above features
- When selected by the user, the image maps onto the object
- In Addition to texture mapping, this part also includes "**Shadows for a 3D Cube**" and "**Lighting for different 3D Objects (Cone, Cylinder, and Sphere)**"

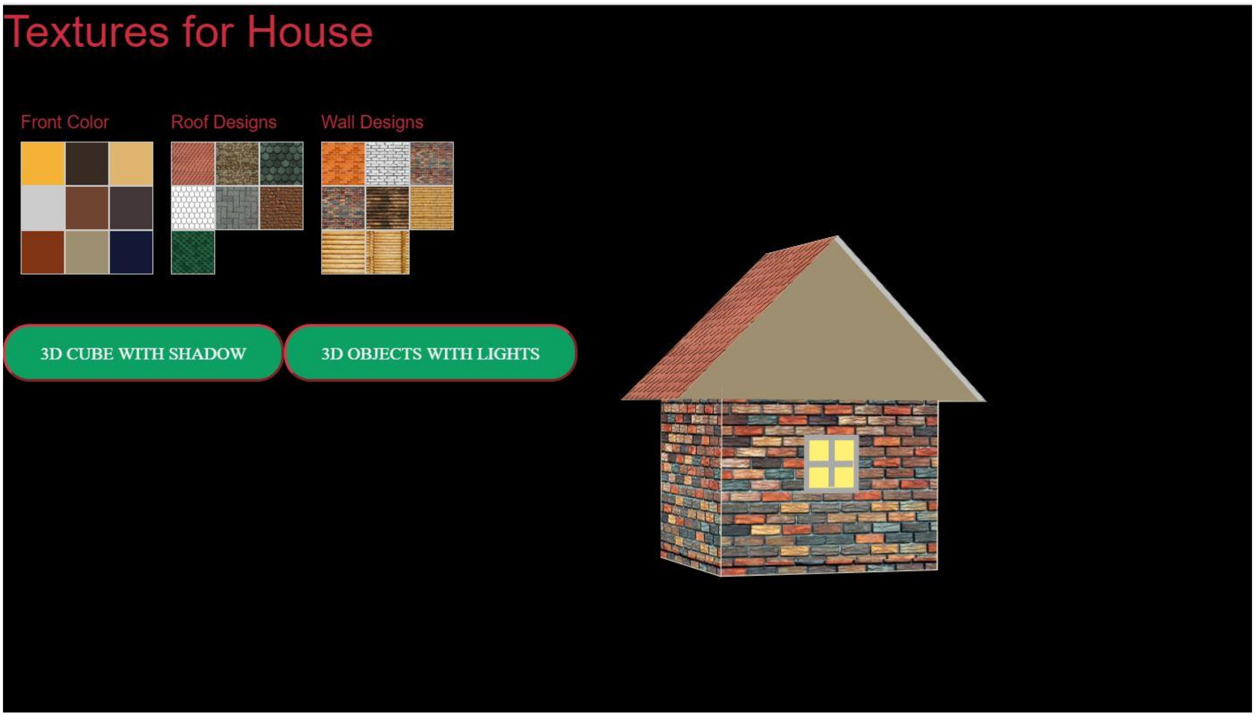
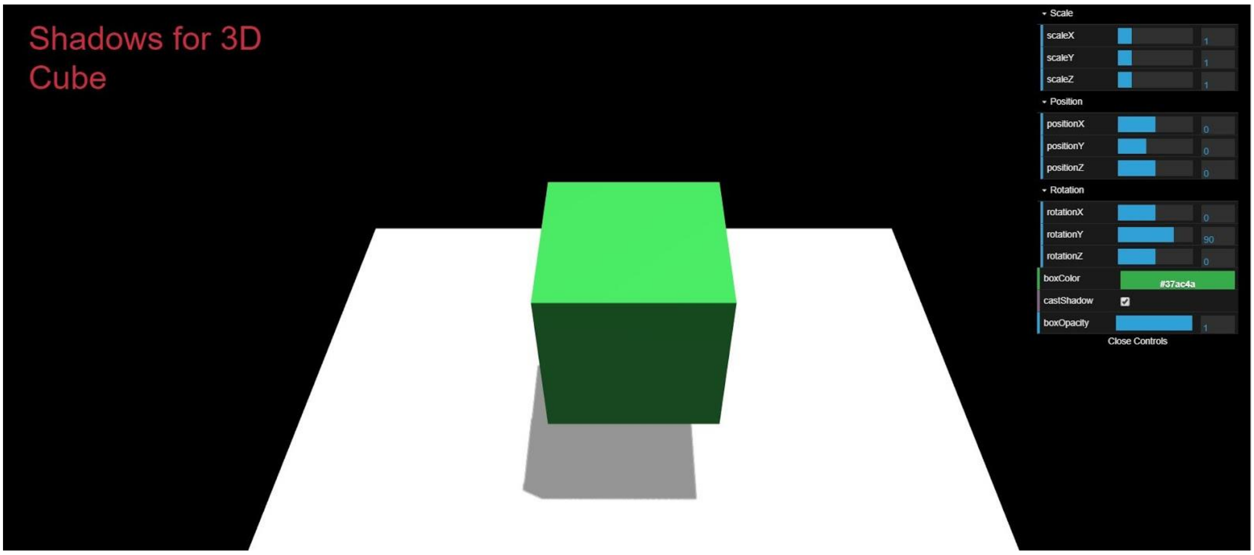


Fig5: Part 4 of the project showing Texture Mapping for House

- For this part, Three.js framework was used
- Features implemented are:
  1. **Scaling** on X,Y,Z Coordinates
  2. **Position** on X,Y,Z Coordinates
  3. **Rotation** on X,Y,Z Coordinates
  4. **Shadow** (Option to disable Shadow is also provided)
  5. Option to change **Cube Color**
  6. **Cube Opacity**



Scale

scaleX	1
scaleY	1
scaleZ	1

Position

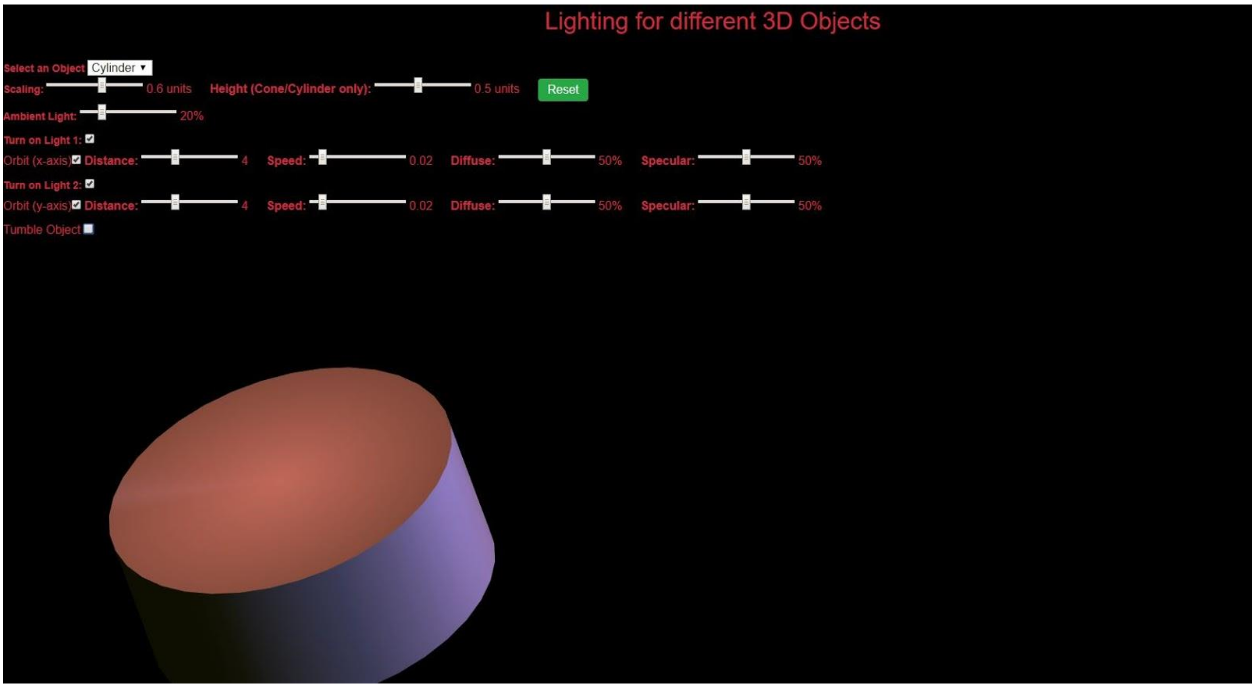
positionX	0
positionY	0
positionZ	0

Rotation

rotationX	0
rotationY	90
rotationZ	0
boxColor	#37ac4a
castShadow	☑
boxOpacity	1

- For implementing Lighting with different 3D Objects, WebGL was used
- Created 3 objects Sphere, Cylinder and Cone for which Lighting is demonstrated.
- Features include:

1. **Scaling**
2. **Height adjustment for Cone and Cylinder**
3. **Ambient Lighting**
4. **Diffusion Lighting**
5. **Specular Lighting**
6. **Speed of Light**
7. **Distance of Light Source**
8. **Option to turn the Lights on/off**
9. **Tumble Object** allows the user to understand the Lighting effect on the object and get a better view



Lighting for different 3D Objects

Select an Object Cylinder ▾

Scaling: 0.6 units Height (Cone/Cylinder only): 0.5 units

Ambient Light: 20%

Turn on Light 1: ☑

Orbit (x-axis)☑ Distance: 4 Speed: 0.02 Diffuse: 50% Specular: 50%

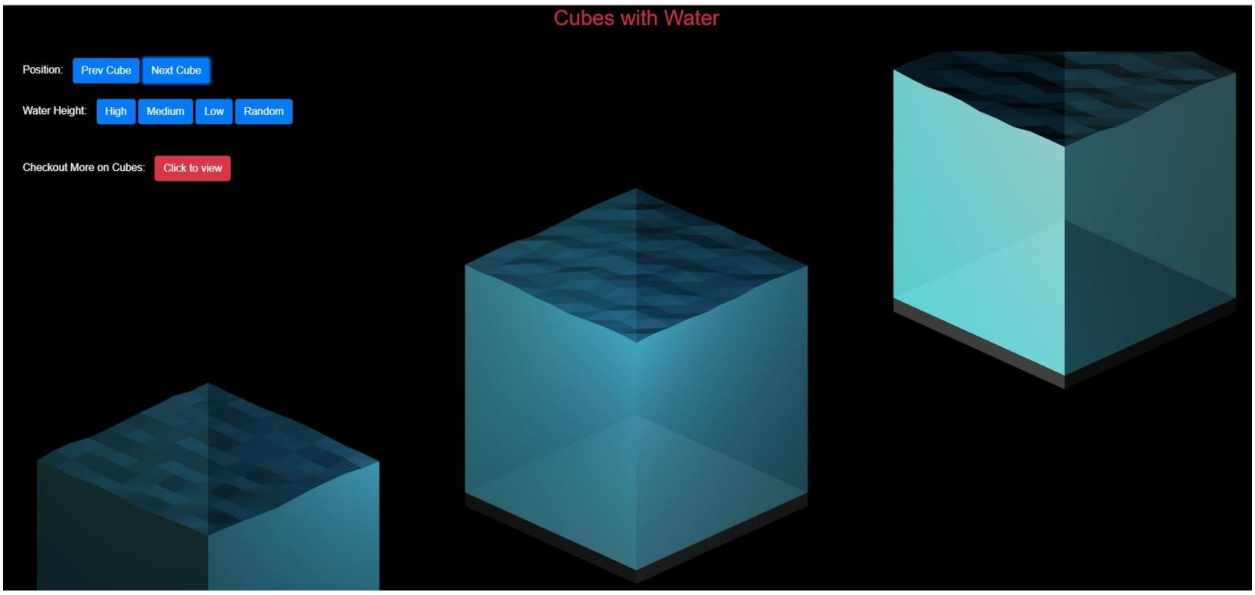
Turn on Light 2: ☑

Orbit (y-axis)☑ Distance: 4 Speed: 0.02 Diffuse: 50% Specular: 50%

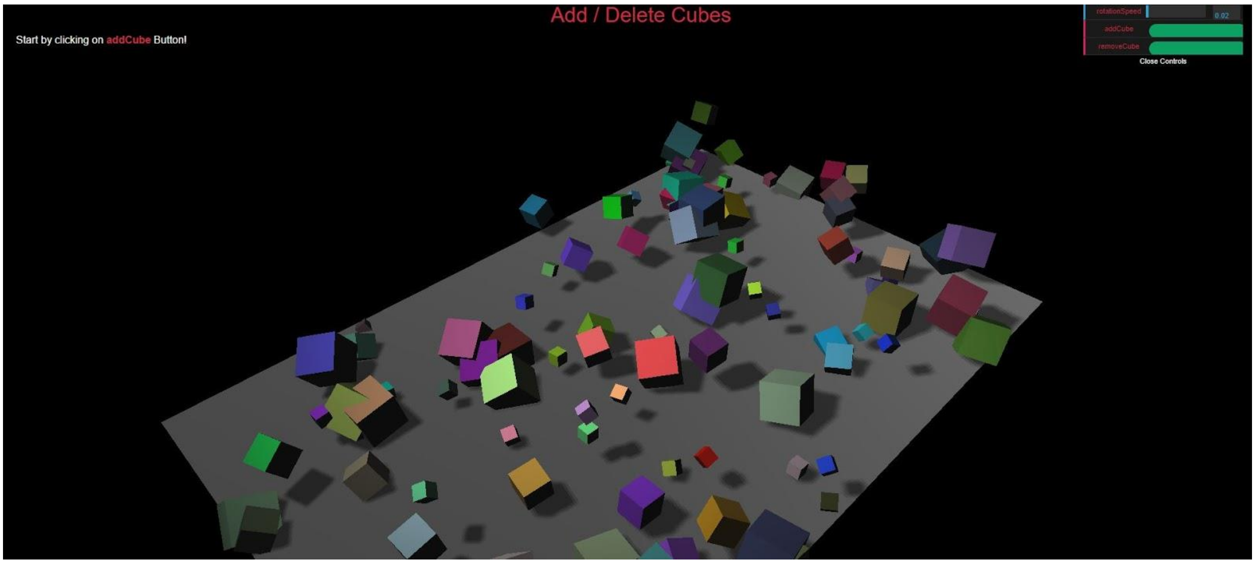
Tumble Object □

Week 5 - More with Camera, Material, Lighting, Views and Animations

- Extending the previous work on Cubes, this part includes implementation of Cubes with Three.js framework
- Features demostrated are:
  1. Cubes with Water are created
  2. Point Lighting
  3. Orthographic Camera
  4. Meshing to water surface
  5. Animations
- Water Levels can be toggled by the user, three levels i.e High, Medium, Low and also a random level can be chosen



- There is a button on this page which directs to an additional part for this week:
  1. Demonstrated a surface where user can **add/ create a number of cubes** just by clicking on a button
  2. **change their rotation speeds**
  3. User can also **delete the cubes** that are created.

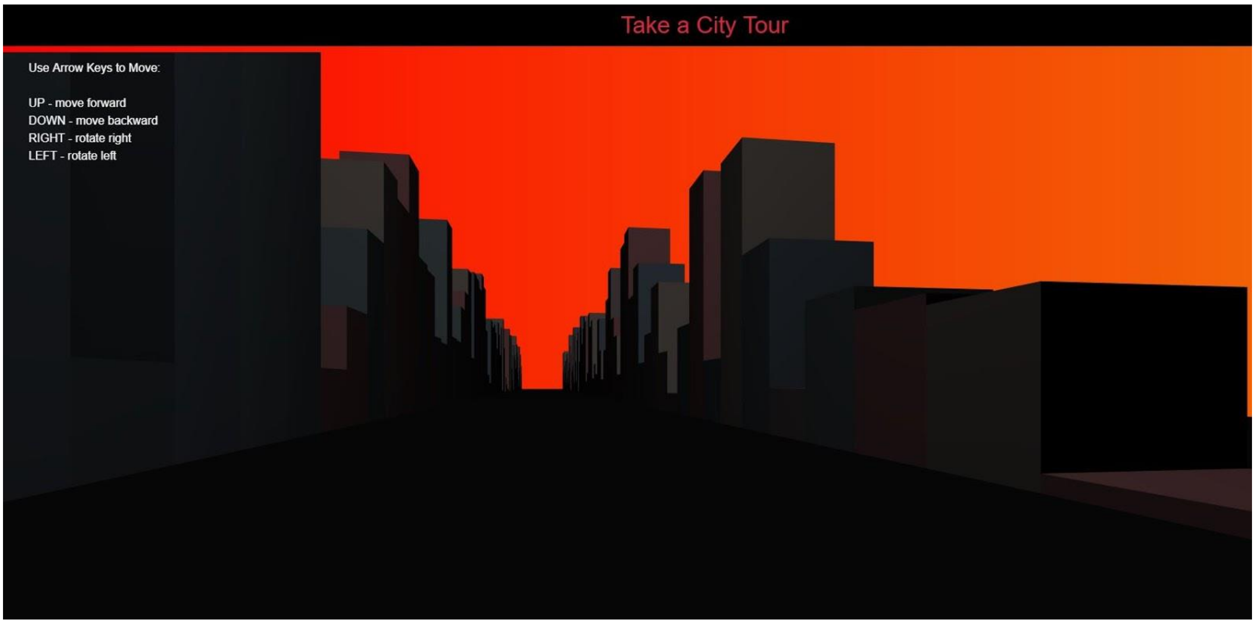


Start by clicking on addCube Button!

Week 6 / Final Week - City Tour using 3D Cubes

- Final part of this project demonstrates a City tour made by creating large number of cubes making them look like buildings
- User is provided keyboard controls to walk around the "city"
- Allows user to get a 360-degree view
- Features implemented are:
  1. Shadows

    2. Point Lighting
    3. Perspective Camera
    4. Views/ Perspectives
    5. Animations
- Also used a linear gradient, which makes the background look like a sunset-sky.



Take a City Tour

Use Arrow Keys to Move:

UP - move forward
DOWN - move backward
RIGHT - rotate right
LEFT - rotate left

Conclusion

Summary of the project along with the list of features are given as follows:

1. Created 3D Objects - House, Cube, Sphere, Cone, Cylinder
2. 2D Transformations - Translate, Rotate, Scale, Shear
3. Views for 2D - Top, Side, Front Views
4. 3D Transformations- Translate, Rotate, Scale
5. Perspective/ Parallel Projection - (One-Point, Two-Point, Three-Point, Orthographic)
6. Texture Mapping for House, Sphere
7. Lighting for different objects (Point, Specular, Diffusion, Ambient, Directional)
8. Shadows for different objects
9. Camera (Orthographic, Perspective)

Additional Features:

1. Animations
2. Gradients for Styling
3. Interactive UI
4. Opacity
5. Position with respect to Observer
6. Orientation with respect to Observer
7. Wireframe 3D Model (House)
8. Meshing
9. Material

References

1. https://threejs.org/docs/index.html#manual/introduction/Creating-a-scene
2. https://developer.mozilla.org/en-US/docs/Web/API/WebGL_API
3. https://www.w3schools.com/graphics/canvas_intro.asp
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5. Youtube WebGL Tutorials
6. https://www.w3schools.com/css/css3_gradients.asp
7. https://getbootstrap.com/docs/4.1/getting-started/introduction/
8. http://colormind.io/bootstrap/