Computer Graphics I

Submitted by Zubin Bhuyan

Project Report
Week 5

So far a 3D house structure, along with options to shear, rotate, and add lights to the scene have been implemented. An option to cast shadow on a plane below also has been added. Fig. 1 is the screenshots of the webpage.

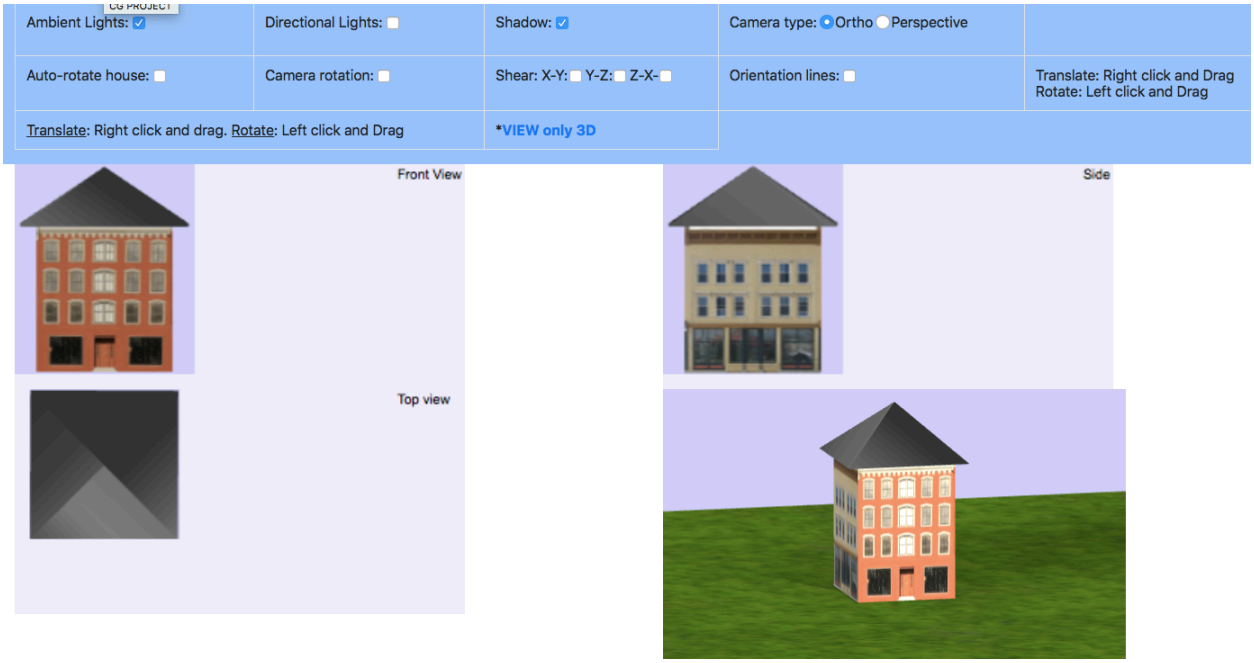

Fig. 1 Screenshot of the webpage.

Languages & libraries

The javascript library, THREE.js is used to define and render the objects and environment. This library is based on the WebGL open source library [1]. THREE.js library is available under the MIT license [2].

Viewing, transformations & projection

The object can be viewed from multiple directions. Simple mouse movements and keyboard inputs can be used to perform basic transformations. And the camera is set for perspective projection.

View direction can be set by clicking and dragging the left mouse button. Translation can either be performed by using the keyboard arrows, or bu right clicking and dragging. The zoom operation can be performed by scrolling in and out.

Lighting, Texture and Material

Several light sources have been used to illustrate how lighting affects a scene. The webpage has option to turn on or off *ambient light* and two sources of directions light. Fig. 2 shows different types of lights which can be used.

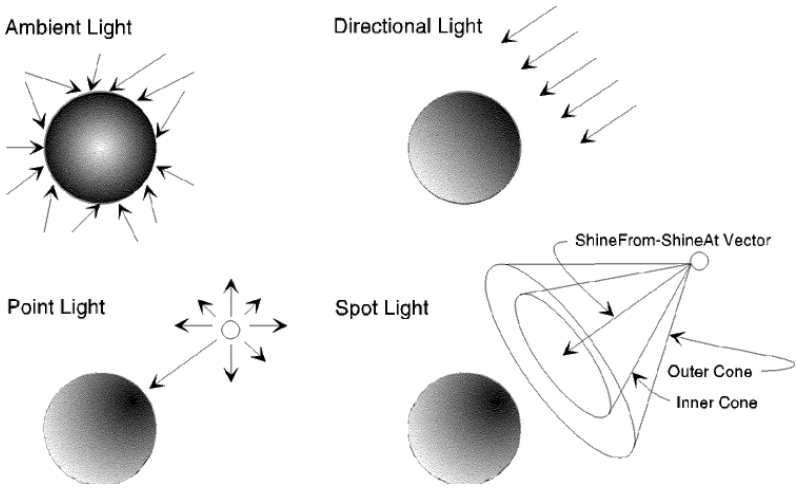

Fig. 2 Types of common light sources. The darker shades indicate higher intensity of light.

The type of material plays a crucial role in determining how the final objects are rendered. In this project, the two materials used are *basic material* and *Phong materials* on the surface of the building. (Refer to [3, 4] for more details.) Fig 3 lists common material types.

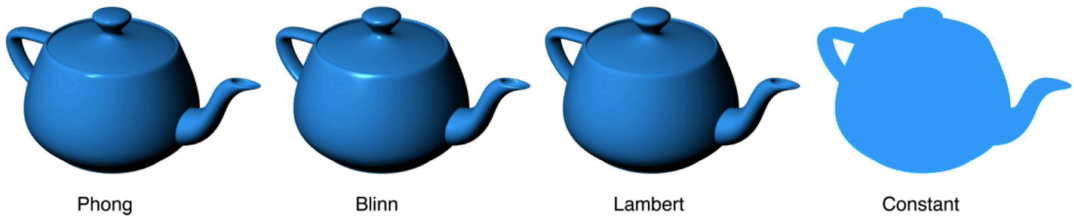

Fig 3 Common material types.

WEEK 2 updates

1. Option to choose camera types has been added (**Orthographic and perspective**).The scene is rendered with a new camera every time the radio button selection is changed.
2. Skew option along 3 axes.
    1. Skewing can be done individually for each axis.
3. Front, side and top view canvases are added.
4. The webpage has been made responsive with ***bootstrap grid***.

Shearing

Shearing is the transformation which slants the shape of an object. In 2-D it can be defined using the matrix X_{sh}:

$$X_{sh} = \begin{bmatrix} 1 & 0 & 0 \\ shx & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$X' = X + Sh_x \cdot Y$$

$$Y' = Y$$

```
var matrix = new THREE.Matrix4();

matrix.set(   1,   Syx,  Szx,  0,
            Sxy,     1,  Szy,  0,
            Sxz,   Syz,    1,  0,
              0,     0,    0,  1  );

// apply shear matrix to geometry
cube.geometry.applyMatrix( matrix );
scene.add( cube );
```

Fig. 3 shows the code snippet which is used to skew cube shapes in THREE.js.

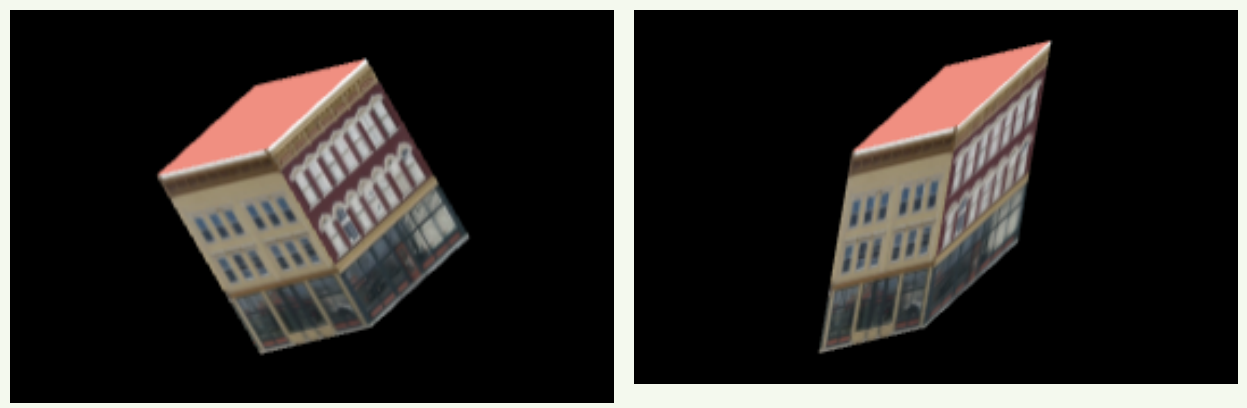

Fig 4. Normal image and a Skewed image (Orthographic)

Orthographic vs Perspective

The following images show the difference between the perspective and orthographic cameras.

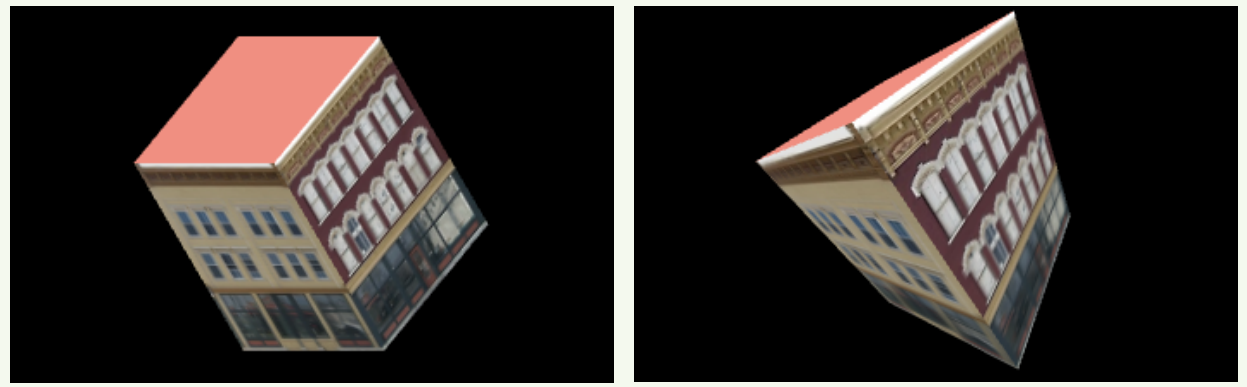

Fig 5 a, b. Orthographic and Perspective camera for the same object.

Week 3 updates

1. Anti-aliasing for the renderer has been enabled.
2. Orientation lines: A check box to show or hide orientation.
3. Option to cast shadow on a plane below the structure.

Shadows

Fig 6 illustrates how shadows are rendered. The near and far planes (with black crosses), and the top/left/bottom/right of the shadow camera define a box. This box has to bind objects needed for shadows. (Refer to [5] for more details on lighting and shadows.)

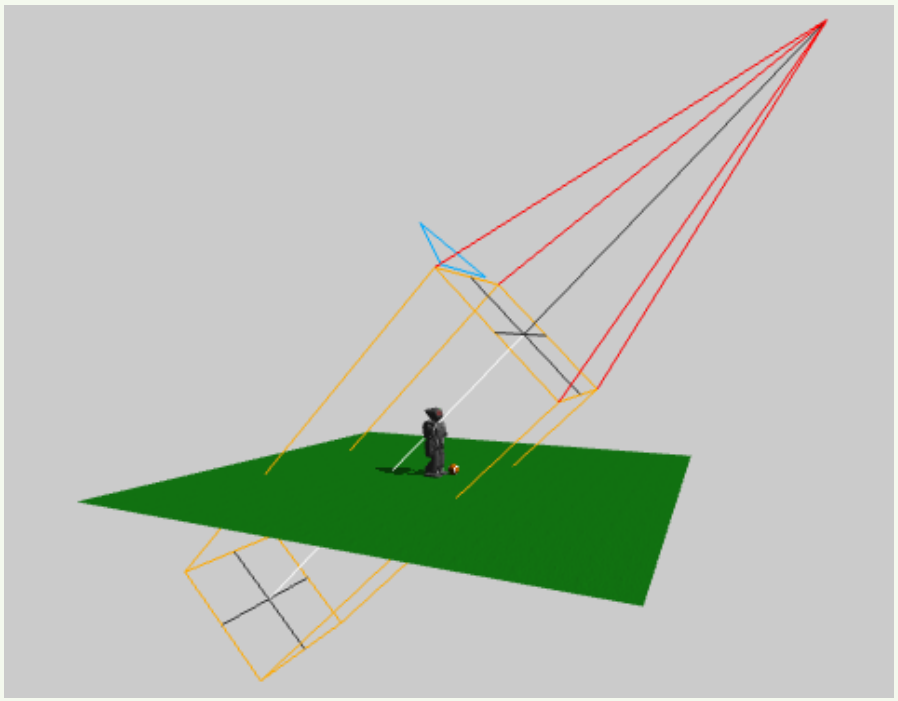

Fig 6. Shadow rendering.

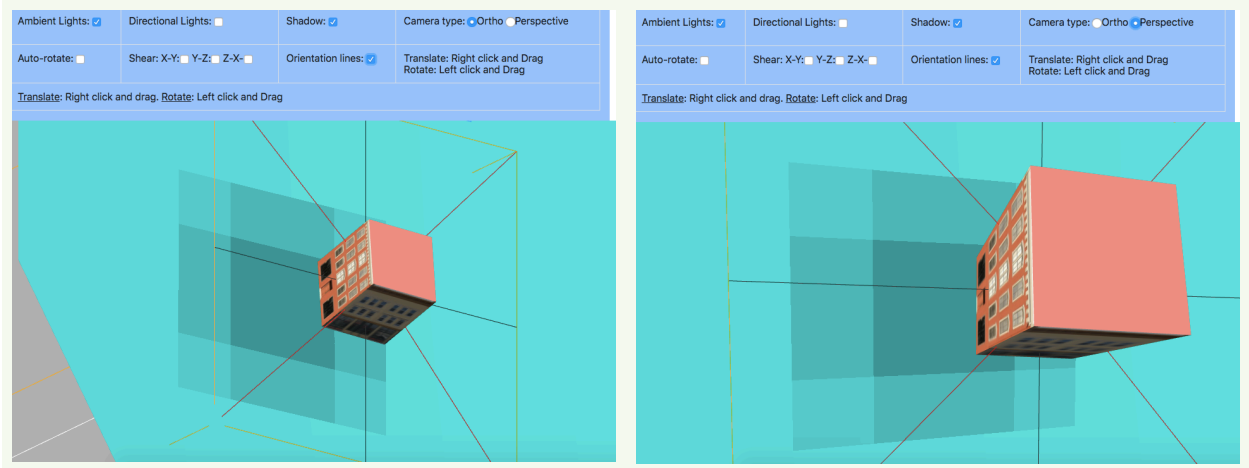

Fig 7 a, b Shadow rendering without Percentage closer Filtering (PCF) for both Orthographic and Perspective

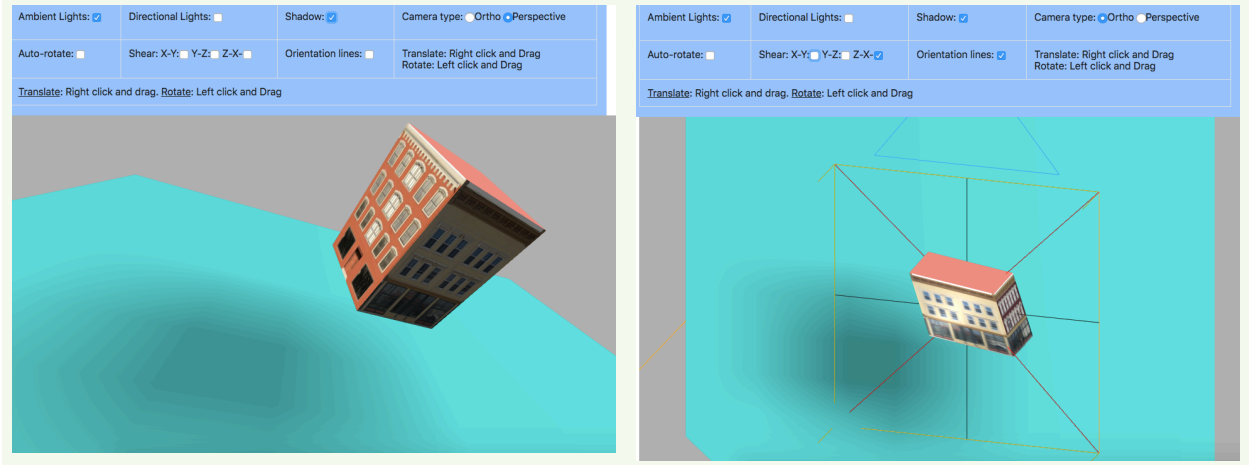

Fig 8 a, b PCF Shadow rendering. Fig 8b shows shadow casting with a sheared structure with helper orientation lines switched on.

Week 4 updates

The main updates of Week 4 are:

1. Ground added below the house
2. Grass texture added to the ground plane
3. Option for Camera Rotation

A ground plane has been added below the house. The shadow of the house is now cast on the ground. Fig. 9 is the grass image used for the grass texture. The image is repeated along X and Y axis.

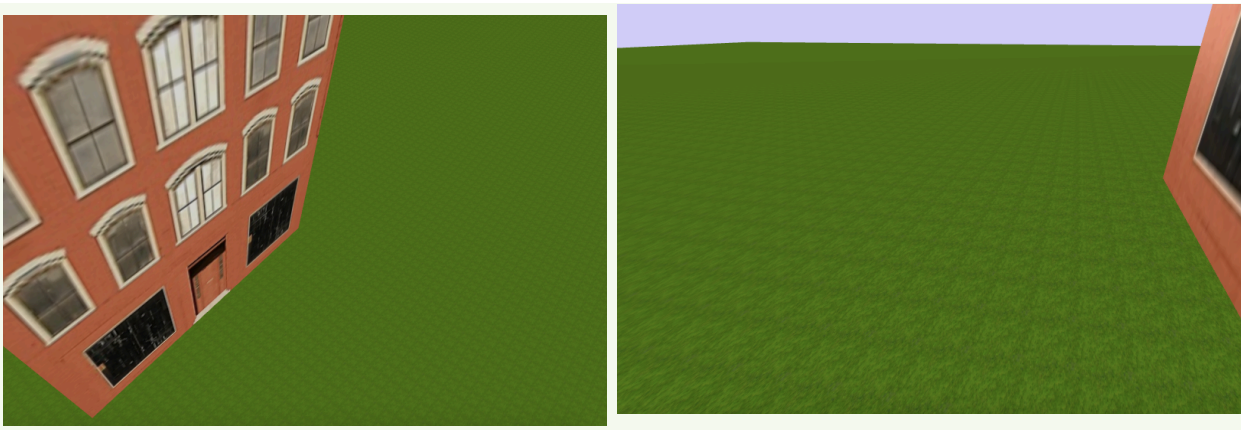

Fig 11 a, b Grass texture as seen from different camera positions.

Fig. 9 Grass image which is repeated along X and Y

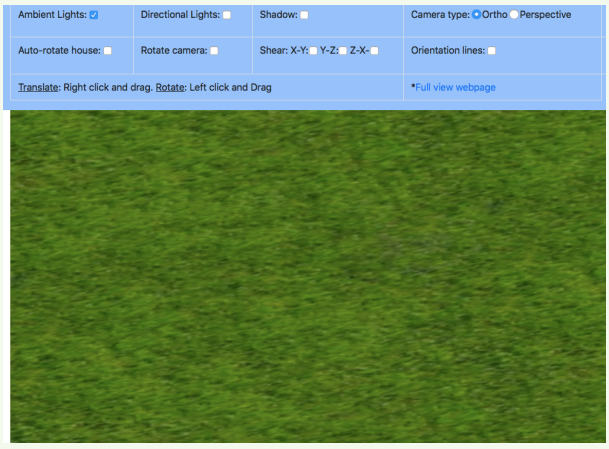

Fig 10 Grass appearance when the camera is very close to the plane.

The grass on the ground appears when the camera is very close to the plane. This can be seen in Fig. 10.

Week 5

Following are the updates for Week 5:

1. Geometry merging for roof and house body.
2. Option to resize house width and breadth.
   2.1.Resize house size from the side view and front view window.
   2.2.Side, front and top views reflect the actual dimension of the house.

The house structure previously did not have a roof structure. As seen in Fig. 11, roof has been added in this update.

Fig 11. The house with the. roof structure.

Merging solids

The UNION operation of Constructive Solid Geometry [6] is used to combine a cube and pyramid geometric structure. The textures have been applied later. Fig 12 a and b show how the two structures appear when they are placed with a separation and when they are merged.

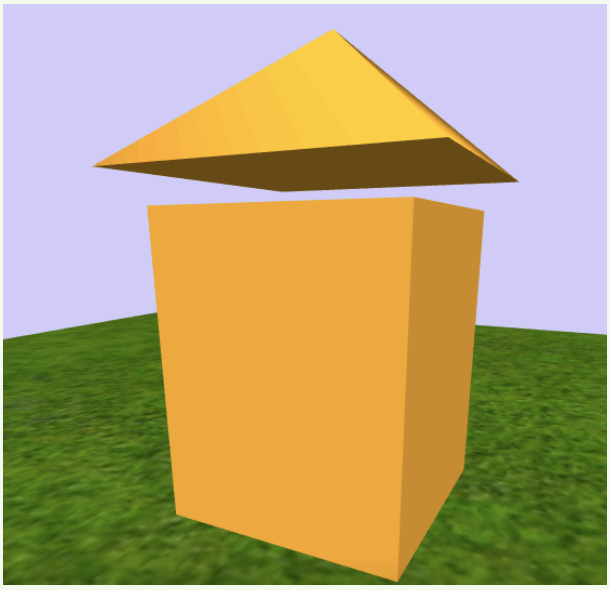

Fig 12 a Two structures placed separately.

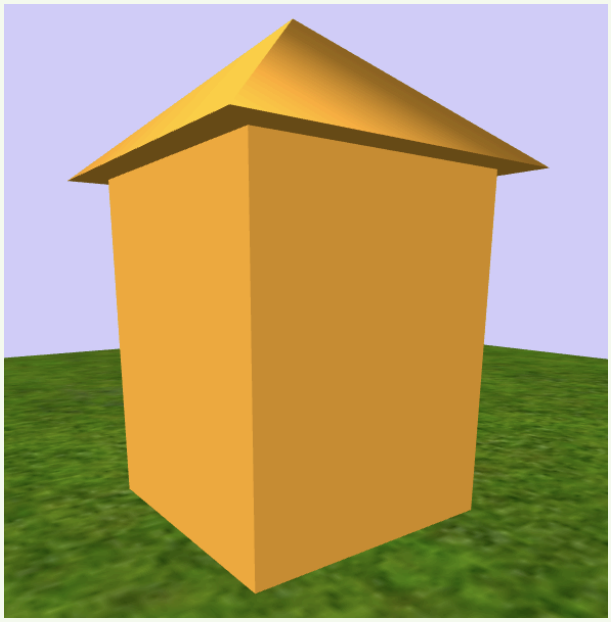

Fig 12 b. Two structures merged to form a combined geometry.

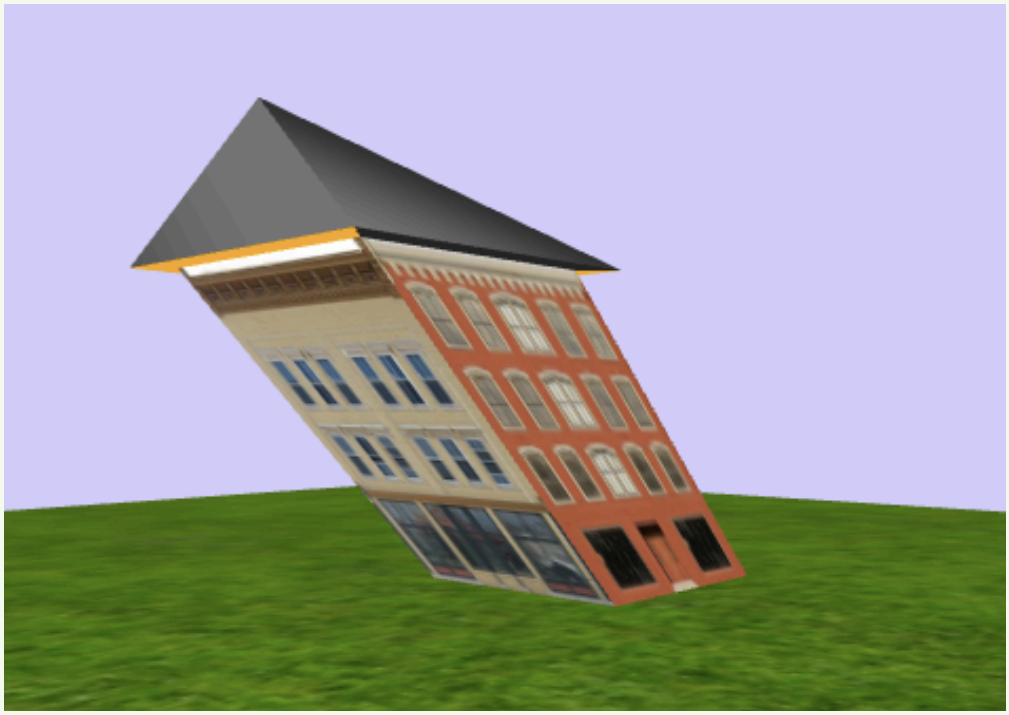

Fig 13 Combined geometry skewed along XY axis.

The merged geometric structure behaves as a single unit even when shear operation is applied on it. This is shown in Fig 13.

Changing size from view canvases

The size of the house can now be altered from the front view and side views. The corresponding change in dimension is also updated in the top view. This is shown in Fig. 14 and Fig 15.

Fig 14 Default house dimension.

Fig 15 The house dimension can be changed in real time from the side view and front view window.

References & bibliography

[1] Khronos Group, WebGL, 2017 (stable), https://github.com/KhronosGroup/WebGL , https://www.khronos.org/webgl/

[2] Ricardo Cabelloa, Three.JS, 2018, https://github.com/mrdoob/three.js , https://threejs.org

[3] Raimond Tunnel, Jaanus Jaggo, Margus Luik, Shading and Lighting, Computer Graphics Learning Materials, 2012, https://cglearn.codelight.eu/pub/computer-graphics/shading-and-lighting

[4] David J. Eck, Lighting and Material, Introduction to Computer Graphics, 2018, http://math.hws.edu/graphicsbook/c7/s2.html

[5] David J. Eck, Introduction to Lighting, Introduction to Computer Graphics, 2018, http://math.hws.edu/graphicsbook/c4/s1.html

[6] Foley, James D. (1996), "12.7 Constructive Solid Geometry", Computer Graphics: Principles and Practice, Addison-Wesley Professional, pp. 557–558