Introduction to Computer Graphics with WebGL

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Computer Viewing
Positioning the Camera

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Objectives

• Introduce the mathematics of projection
• Introduce WebGL viewing functions in MV.js
• Look at alternate viewing APIs
From the Beginning

• In the beginning:
  - fixed function pipeline
  - Model-View and Projection Transformation
  - Predefined frames: model, object, camera, clip, ndc, window

• After deprecation
  - pipeline with programmable shaders
  - no transformations
  - clip, ndc window frames

• MV.js reintroduces original capabilities
Computer Viewing

• There are three aspects of the viewing process, all of which are implemented in the pipeline,
  - Positioning the camera
    • Setting the model-view matrix
  - Selecting a lens
    • Setting the projection matrix
  - Clipping
    • Setting the view volume
The WebGL Camera

- In WebGL, initially the object and camera frames are the same
  - Default model-view matrix is an identity
- The camera is located at origin and points in the negative z direction
- WebGL also specifies a default view volume that is a cube with sides of length 2 centered at the origin
  - Default projection matrix is an identity
Default Projection

Default projection is orthogonal

clipped out

Projection plane  \( z=0 \)
Moving the Camera Frame

• If we want to visualize objects with both positive and negative z values we can either
  - Move the camera in the positive z direction
    • Translate the camera frame
  - Move the objects in the negative z direction
    • Translate the world frame

• Both of these views are equivalent and are determined by the model-view matrix
  - Want a translation ($\text{translate}(0.0, 0.0, -d);$)
    \[-d > 0\]
Moving Camera back from Origin

frames after translation by \(-d\)

\[ d > 0 \]

default frames

(a) frames

(b) frames
Moving the Camera

- We can move the camera to any desired position by a sequence of rotations and translations.
- Example: side view
  - Rotate the camera
  - Move it away from origin
  - Model-view matrix $C = TR$
• Remember that last transformation specified is first to be applied

```javascript
// Using MV.js

var t = translate (0.0, 0.0, -d);
var ry = rotateY(90.0);
var m = mult(t, ry);

or

var m = mult(translate (0.0, 0.0, -d),
             rotateY(90.0));
```
LookAt(eye, at, up)
The lookAt Function

- The GLU library contained the function `gluLookAt` to form the required modelview matrix through a simple interface.
- Note the need for setting an up direction.
- Replaced by `lookAt()` in MV.js - Can concatenate with modeling transformations.
- Example: isometric view of cube aligned with axes.

```javascript
var eye = vec3(1.0, 1.0, 1.0);
var at = vec3(0.0, 0.0, 0.0);
var up = vec3(0.0, 1.0, 0.0);

var mv = LookAt(eye, at, up);
```
Other Viewing APIs

• The LookAt function is only one possible API for positioning the camera

• Others include
  - View reference point, view plane normal, view up (PHIGS, GKS-3D)
  - Yaw, pitch, roll
  - Elevation, azimuth, twist
  - Direction angles