WebGL: GPU Acceleration for the open web

Guest Lecture: Patrick Cozzi
Analytical Graphics, Inc.
University of Pennsylvania

Goals
- Entice you to use WebGL by showing:
  - How WebGL brings 3D to the masses
  - The joys of JavaScript
  - Demos galore
- OpenGL experience is assumed; web experience is not

What do I do?
- OpenGL Insights
- Analytical Graphics, Inc.
- developer
- lecturer
- author
- editor

WebGL for Web Developers
- The web has
  - Text
  - Images
  - Video
- What is the next media-type?
WebGL for Web Developers

- The web has
  - Text
  - Images
  - Video
- What is the next media-type?

3D

WebGL for Graphics Developers

- We want to support
  - Windows, Linux, Mac
  - Desktop and mobile
- How?

Bring 3D to the Masses

- Put it in on a webpage
  - Does not require a plugin or install
  - Does not require administrator rights
- Make it run on most GPUs

Demos

- Google Body
  - http://bodybrowser.googlelabs.com/
- EmberWind
  - http://operasoftware.github.com/Emberwind/
WebGL

- OpenGL ES 2.0 for JavaScript
  - Seriously, JavaScript

WebGL

- Includes
  - Vertex shaders
  - Fragment shaders
  - Vertex buffers
  - Textures
  - Framebuffers
  - Render states
  - ...

WebGL

- Does not include
  - Geometry shaders
  - Tessellation shaders
  - Vertex Array Objects
  - Multiple render targets
  - Floating-point textures
  - Compressed textures
  - FS depth writes
  - ...

WebGL

- Also lacks the latest bells and whistles
  - Atomics
  - Texture load store
  - ...

- But is a very capable graphics API that is supported by lots of GPUs

WebGL

- If you know OpenGL, you already know WebGL
- If you know C++, the real learning curve is JavaScript
WebGL Alternatives?

- Flash
- Silverlight
- Java Applets
- Unity

WebGL

- Creating a context is easy:

  ```html
  // HTML:
  <canvas id="glCanvas" width="1024"
          height="768"></canvas>
  ```

  ```javascript
  // JavaScript:
  var gl =
    document.getElementById("glCanvas")
     .getContext("experimental-webgl");
  ```

- The rest is similar to desktop OpenGL:

  ```javascript
  // ...
  gl.bindBuffer(/* ... */);
  gl.vertexAttribPointer(/* ... */);
  gl.useProgram(/* ... */);
  gl.drawArrays(/* ... */);
  ```

WebGL

- Create an animation loop:

  ```javascript
  (function tick(){
    // ... GL calls to draw scene
    window.requestAnimationFrame(tick);
  })();
  ```

Checkout [http://learningwebgl.com](http://learningwebgl.com)

WebGL Performance

- Performance can be very good. Why?
  - The GPU is still doing the rendering
  - Batch!
    - Draw multiple objects with one draw call
    - Sort by texture
    - Push work into shaders

See http://www.youtube.com/watch?v=rQ8kGTG7Q

WebGL and other APIs

- Take advantage of other web APIs:
  - HTML5 <video>
  - 2D <canvas>
  - CSS transforms
  - Composite UI elements
  - Web workers
  - Typed Arrays

WebGL Skin
http://alteredqualia.com/three/examples/webgl_materials_skin.html

WebGL Water
http://madebyevan.com/webgl-water.html

Demos
WebGL support is good, and it is getting better…

In September, 2011

Desktop WebGL Support
- Windows Only

3rd Party Plugins available

See http://www.khronos.org/webgl/wiki/Getting_a_WebGL_Implementation

See http://people.mozilla.org/~bjacob/gfx_features_stats/

% Firefox users on Windows 7 with WebGL support (blue)

% Firefox users on Windows XP with WebGL support (blue)

See http://people.mozilla.org/~bjacob/gfx_features_stats

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Desktop WebGL Support

- Windows
  - No OpenGL driver installed? Old driver?
    - Only 35% of Windows XP machines have GL 2 drivers
  - Buggy driver?
  - No problem:
    - ANGLE – Almost Native Graphics Layer Engine

Mobile WebGL Support

- In September, 2011
  - Firefox Mobile – “Fennec”
    - Performance improvements possibly this year
  - Stock Browser
    - Demo at SIGGRAPH 2011. NVIDIA is working on it
Mobile WebGL Support

- In September, 2011
- Will be in iOS 5 for iAd developers

See http://news.cnet.com/8301-30685_3-20071902-25لاق pre-sings-up-for-webgl-graphics-in-iads/

HTML5 on Mobile

- Touch events
  - Test with http://www.snappymaria.com/misc/TouchEventTest_v2.html
  - Still need multi-touch in Firefox Mobile
- Geolocation
- Device orientation and motion

- The future of HTML5 and WebGL on mobile is very promising

By the way, mobile is really important:

WebGL Support on your System

- http://webglreport.sourceforge.net/
Browsers are becoming like operating systems...

Browser Architecture

- Single Process
  - UI
  - Networking
  - File Access
  - HTML Rendering
  - JavaScript execution
  - Graphics
  - ...

Chrome’s Multi-process

Browser Process
- UI, Networking, File Access

Render Process
- JavaScript execution (V8), HTML rendering (WebKit), WebGL, etc.

Browser Process
- UI, Networking, File Access

Render Process 1

Render Process N

Browser Architecture

- **Chrome’s Multi-process**


- In a multi-process is `gl.Get*` slow? Why?

Browser Architecture

- Other browsers also use a multi-process architecture in one form or another

Demos

The Joys of JavaScript

JavaScript is weakly typed…

JavaScript Type System

- short, int, float, double. Who needs them?
  
  ```javascript
  var n = 1;  
  ```

JavaScript Type System

- JavaScript has numbers, strings, and booleans:
  
  ```javascript
  var n = 1;  
  var s = "WebGL";  
  var b = true;  
  ```
JavaScript Type System

- This compiles:

```javascript
var n = 1;
var s = "WebGL";
var b = true;

var sum = n + s + b;
```

JavaScript is a functional language...

JavaScript Functions

- Looks familiar:

```javascript
function add(x, y) {
  return x + y;
}

var sum = add(1, 2);
```

- Functions are first-class objects, so...

```javascript
var add = function(x, y) {
  return x + y;
};

var sum = add(1, 2);
```
JavaScript Functions

- Pass functions to functions:

  ```javascript
  var add = function // ...

  function execute(op, x, y) {
    return op(x, y);
  }

  var sum = execute(add, 1, 2);
  ```

JavaScript Anonymous Functions

- Why name functions?

  ```javascript
  function execute(op, x, y) // ...

  var sum = execute(function(x, y) {
    return x + y;
  }, 1, 2);
  ```

JavaScript Closures

- Why limit scope?

  ```javascript
  var z = 3;

  var sum = execute(function(x, y) {
    return x + y + z;
  }, 1, 2);
  ```

JavaScript is a dynamic language…
JavaScript Object Literals

Who needs **struct**? Create objects on the fly:

```javascript
var position = {
  x : 1.0,
  y : 2.0
};
```

JavaScript Object Literals

Why not add fields on the fly too?

```javascript
var position = {
  x : 1.0,
  y : 2.0
};
position.z = 3.0;
```

JavaScript Object Literals

Who needs **class**?

```javascript
var position = {
  x : 1.0,
  y : 2.0,
  min : function() {
    return Math.min(this.x, this.y);
  }
};
```
JavaScript Object Literals

- Why not change \texttt{min()}?

  ```javascript
  position.z = 3.0;
  position.min = function() {
    return Math.min(this.x, this.y, this.z);
  };
  ```

JavaScript Object Literals

- Useful for passing to functions. Why?
  - What do these arguments mean?

  ```javascript
  pick(322, 40, 5, 4);
  ```

JavaScript Object Literals

- Useful for passing to functions. Why?
  - What do these arguments mean?

  ```javascript
  pick({
    x : 322,
    y : 40,
    width : 5,
    height : 4
  });
  ```
Demos

JavaScript does object-oriented...

JavaScript Constructor Functions

```javascript
function Vector(x, y) {
  this.x = x;
  this.y = y;
}

var v = new Vector(1, 2);
```

JavaScript Constructor Functions

- Objects can have functions:
  ```javascript
  function Vector(x, y) {
    this.x = x;
    this.y = y;
    this.min = function() {
      return Math.min(this.x, this.y);
    };
  }
  ```
JavaScript Constructor Functions

- Objects have prototypes:
  ```javascript
  function Vector(x, y) {
    this.x = x;
    this.y = y;
  }
  Vector.prototype.min = function() {
    return Math.min(this.x, this.y);
  };
  ```

JavaScript Polymorphism

- No need for virtual functions
  ```javascript
  function draw(model) {
    model.setRenderState();
    model.render();
  }
  ```

JavaScript Polymorphism

- No need for virtual functions
  ```javascript
  var level = {
    setRenderState : function() // ...
    render : function() // ...
  };
  ```

JavaScript Build Pipeline

- Different than C++
  - **Goal**: fast downloads
  - **Common**:
    ```javascript
    | js file | Concatenate | One js file | Minify | Compressed js file |
    |---------|------------|-------------|--------|-------------------|
    ```
  - Alternative: fine-grain modules
  - How do you deploy shaders?

JavaScript Advice

- Use JSLint
- Have excellent test coverage
- Use the Chrome and Firefox debuggers

Demos

- The Sproingies
- WebGL Inspector

WebGL developers now need to think about security…

Cross-Origin Resource Sharing

- Images can’t always be used as texture sources. Why?
Cross-Origin Resource Sharing

- Same domain is OK:

```javascript
var img = new Image();
img.onload = function() {
    gl.texImage2D('/', '+', '+', img);
};
img.src = "image.png";
```

Cross-Origin Resource Sharing

- Another domain requires CORS if supported:

```javascript
var img = new Image();
img.onload = function() {
    gl.texImage2D('/', '+', '+', img);
};
img.crossOrigin = "anonymous";
img.src = "http://another-domain.com/image.png";
```

Cross-Origin Resource Sharing

- Not all servers support CORS:

Cross-Origin Resource Sharing

- Use a proxy server:

Denial of Service Attacks

- Long draw calls
  - Complicated shaders
  - Big vertex buffers
- Solutions
  - Kill long draw calls
  - Forbid further rendering

Lots of WebGL security info: http://learningwebgl.com/blog/?p=3890

Demos

Geoscope Sandbox (will be released soon)
http://localhost/geoscopedemos/Build/Debug/Examples/Sandbox/index.html

WebGL Libraries

- Three.js: https://github.com/mrdoob/three.js/
- SceneJS: http://scenejs.org/
- PhiloGL: http://senchalabs.github.com/philogl/
- SpiderGL: http://spidergl.org/

WebGL Resources

- WebGL Camps: http://www.webglcamp.com
- Learning WebGL: http://learningwebgl.com
JavaScript Resources

I promise I do not work for O'Reilly or Yahoo!

By the way, **WebCL** is coming

http://www.khronos.org/webcl/
Prototypes for Firefox and WebKit are available

Interactive WebCL kernel editor:
http://webcl.nokiaresearch.com/kerneltoy/