# Using OpenGL in Java with JOGL

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Consortium for Computing Sciences in Colleges, 2005

# Outline

1. Introduction
2. Tutorial
   - Installing JOGL
   - Tutorial Files
   - Example 1: Basic Framework
   - Example 2: Hello JOGL
   - Example 3: Swing and JOGL
   - Example 4: Animation
   - Example 5: Composable Pipelines
   - Example 6: Textures
   - Example 7: PBuffers
   - Example 8: Multiple Canvases and Shared Data
   - Example 9: Vertex Arrays
   - Example 10: Screen Capture
3. Summary and Discussion

# Java Bindings Under Active Development

## Incomplete List

- LWJGL: Light Weight Java Game Library ( `http://www.lwjgl.org` )
  - Focused on game development
  - Usually full-screen oriented
  - Minimal AWT/Swing integration
  - BSD style license.
- JOGL: ( `http://jogl.dev.java.net` )
  - Good integration with AWT/Swing
  - Under development by employees at Sun
  - Will be used as basis for JSR-231 for integration into Java standard distribution (Java 6.0?)
  - Under BSD license.

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# JSR-231

- Java Community Process (`http://jcp.org` )
- JSR: Java Specification Request
- JSR-231: Java bindings to OpenGL (`http://www.jcp.org/en/jsr/detail?id=231`)
  - JOGL codebase recently forked to JSR-231.
  - Large and small API changes.
  - Package name moving to `javax.media.opengl`. (Currently: `net.java.games.jogl`)
  - Future releases after JOGL 1.1.1 will be under the JSR-231 API.

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# The JOGL Components

- Java class library: `jogl.jar` (platform independent)
- JOGL shared native libraries (platform specific)
  - Windows: `libjogl.dll` and `libjogl_cg.dll`.
  - Linux/UNIX: `libjogl.so` and `libjogl_cg.so`
  - Mac OS X: `libjogl.jnilib` and `libjogl_cg.jnilib`
- Useage:
  - Place `jogl.jar` in CLASSPATH.
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  - `net.java.games.jogl` : Core classes.
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  - `net.java.games.cg` : Classes for use with Cg shading language.
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- Download zip file from: `http://www.cs.plu.edu/~dwolff/talks/jogl-ccsc`
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# Interface `GLDrawable`

- Key implementing classes:
  - `GLCanvas` - “heavyweight” component. Subclass of `java.awt.Canvas`.
    - Some drawing problems when mixing with lightweight components.
  - `GLJPanel` - “lightweight” component. Subclass of `javax.swing.JPanel`
    - Currently implemented using PBuffers
    - Slower performance than `GLCanvas`
    - Expected to improve dramatically with JSR-231
- Selected methods:
  - `void addGLEventListener(GLEventListener)`
  - `GL getGL()`
  - `void setGL(GL gl)`
  - `boolean canCreateOffscreenDrawable()`
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# Creating a `GLCanvas`

- Factory method from `GLDrawableFactory` class.
  - `GLDrawableFactory.getFactory().createGLCanvas(capabilities)`
- Requires an instance of `GLCapabilities`.
  - Specifies a list of requested capabilities (e.g. hw acceleration, bit depth, etc.)
  - Will pick defaults appropriate for driver.
  - No guarantees.
  - Choose alternatives with `GLCapabilitiesChooser` object.

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# The `GLEventListener` Interface

- Follows the standard Java event listener paradigm. Subinterface of `java.util.EventListener`.
- Methods
  - `public void init( GLDrawable d )`
    - Called once on creation.
  - `public void reshape( GLDrawable d, int x, int y, int width, int height)`
    - Called after init and on resize event. (x and y are always zero?).
  - `public void display( GLDrawable d )`
    - Called for each refresh.
  - `public void displayChanged( GLDrawable d, boolean modeChanged, boolean deviceChanged )`
    - Intended for handling multiple monitors, and for changing of resolution or bit depth
    - Currently unimplemented (likely to be removed).

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# Calling GL Functions

- First param for each `GLEventListener` method: `GLDrawable`.
  - The `GLJPanel` or `GLCanvas`.
- `GLDrawable` provides access to `GL` and `GLU` objects.
- All GL functions available through `GL` object.

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    ```
    GL gl = drawable.getGL();
    gl.glPushMatrix();
    gl.glBegin( GL.GL_TRIANGLES );
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  - Recommendation: always retrieve GL object, rather than store as instance variable.

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# Heavyweight component: `GLCanvas`

- Good performance compared to `GLJPanel`
- Integrates with Swing well in nearly all situations.
- Exceptions:
  - `JInternalFrames`
  - `JPopupMenu`s and swing tooltips.
- Workarounds:  
  `JPopupMenu`:
  - `setLightWeightPopupEnabled(false)`
  - `setDefaultLightWeightPopupEnabled(false)`

  `ToolTipManager`
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# Capturing AWT Events

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  - GL/GLU objects should not be used outside.
- Store changes and retrieve on next call to `display()`
- Ways to refresh:
  - `GLDrawable.display()`: blocking.
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- GL context current only in `GLEventListener` methods.
  - GL/GLU objects should not be used outside.
- Store changes and retrieve on next call to `display()`
- Ways to refresh:
  - `GLDrawable.display()`: blocking.
  - `Container.repaint()`: non-blocking.
- Both methods available in `GLCanvas`.

# Threading Issues

- All of the `GLEventListener` methods are executed on the AWT event dispatching thread.
- Future versions may change this.
- `setRenderingThread()` is currently a no-op.
- This is a change from previous versions in response to a variety of threading issues.

# Outline

1. Introduction
2. Tutorial
    - Installing JOGL
    - Tutorial Files
    - Example 1: Basic Framework
    - Example 2: Hello JOGL
    - Example 3: Swing and JOGL
    - Example 4: Animation
    - Example 5: Composable Pipelines
    - Example 6: Textures
    - Example 7: PBuffers
    - Example 8: Multiple Canvases and Shared Data
    - Example 9: Vertex Arrays
    - Example 10: Screen Capture
3. Summary and Discussion

# The `Animator` Class

- Causes continual calls to `display()`
- As fast as possible, no FPS limit.
- Give `GLDrawable` instance to `Animator` upon creation.
- Can be started and stopped repeatedly.
- Can not be started until `GLCanvas` is “realized”
- Starting at the end of `init()` seems to work well

# A Clocked Animator: `FPSAnimator`

- Uses `java.util.Timer`
- Calls `GLDrawable.display()` every x microseconds based on fps.
- JOGL community's `FPSAnimator` possibly unstable.
    - Seems to fail when stopping and restarting on some OSs.

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2. Tutorial
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# Composable Pipelines

- Add additional behaviors to GL pipeline.
- “Wrap” the GL object with new pipeline
  - `drawable.setGL( new <Pipline>(drawable.getGL() ) )`
- Should be done at the beginning of `init()`

# DebugGL and TraceGL

- DebugGL
  - drawable.setGL( new DebugGL(drawable.getGL() ) )
  - Calls glGetError() after each OpenGL call
  - Throws GLException when an error is found
  - This is a distinct advantage over C
- TraceGL
  - drawable.setGL( new TraceGL(drawable.getGL() ) )
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1. Introduction
2. Tutorial
    - Installing JOGL
    - Tutorial Files
    - Example 1: Basic Framework
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# Using `ImageIO` For Loading Images

- `ImageIO.read(...)` returns `BufferedImage`
  - Supports jpg, png, gif
  - Plugins available for tga images.
- Slow?

# Converting `BufferedImage` to OpenGL Format

- `BufferedImage` provides access to pixel data in a variety of formats.
- JOGL prefers `java.nio` direct buffers.
- This example uses `ByteBuffer`:
  - `ByteBuffer.allocateDirect( nBytes );`
- Unpack pixels from `BufferedImage` and pack into `ByteBuffer`.
- `BufferedImage.getRGB(row,col)` returns `int` pixel in ARGB format.

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   - Example 4: Animation
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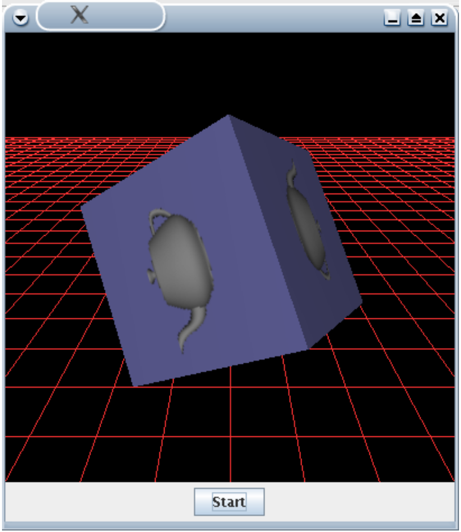
# Creating an Offscreen Drawable

- Support depends on graphics card
- JOGL API is experimental, may change
- Check for support: `drawable.canCreateOffscreenDrawable()`
- `drawable.createOffscreenDrawable(caps, w, h)`
- Returns `GLPbuffer`
- The main drawable, and the Pbuffer may have separate `GLEventListeners`.
- Texture data and display lists are shared.

# Using the PBuffer as a Texture

- Direct render to texture is supported in limited hardware.
- This example: render to Pbuffer, copy pixels to texture.
- At end of `display()` in Pbuffer:
  `glCopyTexImage2D(...)`

# Screenshot



# Outline

1. Introduction
2. Tutorial
   - Installing JOGL
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   - Example 1: Basic Framework
   - Example 2: Hello JOGL
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# Creating Multiple Canvases with Shared Data

- Sharing of display lists, texture data, etc.
- Second parameter to `createGLCanvas()`, is canvas to share with.
  - `...createGLCanvas(caps, otherCanvas)`
- This example shows sharing of display list and two textures.

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   - Example 4: Animation
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# Using `java.nio` Buffers for Vertex Arrays

- Helper methods for creating buffers: `net.java.games.jogl.util.BufferUtils`
- Vertex, normal arrays: `java.nio.DoubleBuffer`
- Index array: `java.nio.IntBuffer`
- Creation: `vertexBuffer = BufferUtils.newDoubleBuffer( nDoubles )`
- Append triple: `vertexBuffer.put( vertex )`
- Give to OpenGL: `gl.glVertexPointer(3, GL.GL_DOUBLE, 0, vertexBuffer)`

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# Retrieving the Frame Buffer Using `GLReadPixels`

- Copy frame buffer into `ByteBuffer`
  - Allocate buffer: `BufferUtils.newByteBuffer(w*h*3)`
  - Copy pixels: `gl.glReadPixels(..., GL.GL_RGB, GL.GL_UNSIGNED_BYTE, ...)`
- Move from buffer into `BufferedImage`
  - Swap bytes, pack into `int[]`
  - Set data in `BufferedImage`: `img.setRGB(...)`
- Save image to file using `ImageIO`:
  - `ImageIO.write( img, "PNG", file )`

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# Java Web Start

- Deploy JOGL apps via web link.
- JNLP (Java Network Launch Protocol) file:
  - XML based
  - Point to jar file and JOGL libraries.
  - Pre-defined jnlp for JOGL libs hosted at: `https://jogl.dev.java.net/webstart/jogl.jnlp`
  - Will select appropriate native libs.
  - Avoids security headaches (signed by Sun with VeriSign cert.)
- Web server must supply correct MIME type: `application/x-java-jnlp-file`

# Scenegraph Support

- Scenegraph: Xith 3D ( `http://xith.org` )
  - Built on JOGL (or LWJGL)
  - Provides access to OpenGL commands
  - Alternative to Java3D, using similar structure
  - Includes 3ds loader.

# Game Programming

- Quake 2 engine developed by Clark et al. for instructional purposes, written in JOGL. (JCSC V. (20) 2, December 2004)
- Full featured Quake 2 engine (open source) called Jake 2, developed using JOGL.
    - `http://www.bytonic.de`
    - Benchmarks: “Fast JOGL” 250 fps vs Original C code 315 fps.

# Java in Intro. Graphics

- Pro
  - Spend less time on C++ review, and more on graphics
  - Can use the Java Collection classes instead of the STL
  - No need for a windowing toolkit such as GLUT, Qt, etc.
  - Graphics is difficult enough without C++
- Con
  - C++ is industry standard for 3D graphics
  - Performance
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# JOGL in Intro. Computer Graphics at PLU

- Previous experiments: GLUT, Qt
- At PLU: CS1/2 are taught in Java.
- STL skills?
- Java Collection API: Familiar, no extra instruction
- Student job market preparation

# Thanks!

- Tutorial materials: `http://www.cs.plu.edu/~dwolff/talks/jogl-ccsc`
- Contact: `daw@plu.edu`
- Questions?