Android and OpenGL

Android Smartphone Programming

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Outline

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OpenGL Introduction

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- Short for: Open Graphics Library[4].
- Enables creation of 2D and 3D graphics.
- Special API for embedded systems available on Android: *OpenGL ES API*.
- Two important classes: *GLSurfaceView* and *GLSurfaceView.Renderer*.

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OpenGL Introduction
Important Classes
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GLSurfaceView View to draw and manipulate objects using OpenGL.

GLSurfaceView.Renderer Interface defining methods to draw (render) graphics.

- Add renderer to GLSurfaceView using *GLSurfaceView.setRenderer()*.
- Extend GLSurfaceView to capture touch screen events.
- Extend Android manifest when using OpenGL ES 2.0:

```
1 <!-- Tell the system this app requires OpenGL
      ES 2.0. -->
2 <uses-feature android:glEsVersion="0x00020000
     " android:required="true" />
```

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OpenGL Introduction
Example
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```
1 class MyGLSurfaceView extends GLSurfaceView {
2   public MyGLSurfaceView(Context context){
3     super(context);
4     setRenderer(new MyRenderer());
5     // Called when using OpenGL ES 2.0
6     setEGLContextClientVersion(2);
7   }
8 }
```

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OpenGL Introduction
GLSurfaceView.Renderer
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- Includes three methods to be implemented to draw graphics.

onSurfaceCreated() Called once when creating the GLSurfaceView.

Should include all actions to do only once.

onDrawFrame() Called on each redraw of GLSurfaceView.

Do all drawing and redrawing of graphic objects here.

onSurfaceChanged() Called when the geometry of GLSurfaceView changes, for example size screen or orientation.

Add code to respond to those changes.

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OpenGL Introduction
Versions
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- Two different OpenGL ES API versions available: 1.0 (together with version 1.1 extensions) and 2.0.
- Both usable to create high performance graphics for 3D games and visualizations.
- Grapic programming for one of the versions differs significantly to programming for the other version.
- Version 1.0/1.1 is easier to use as there are more convenience methods available.
- Version 2.0 provides higher degree of control, enabling creating of effects that are hard to realize in version 1.0/1.1.

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Displaying Graphics
Defining Shapes
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- Shapes are graphic objects to be drawn in OpenGL.
- Shapes are defined using three-dimensional coordinates.
- Coordinates get written into *ByteBuffer* that is passed into the graphics pipeline for processing.
- Coordinate format: [X, Y, Z]
- Examples: Center of view: [0,0,0], top right corner: [1,1,0], bottom left corner: [-1,-1,0].

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Displaying Graphics
Example: Defining Triangle
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```
1 class Triangle {
2   private FloatBuffer vertexBuffer; ...
3   public Triangle() {
4     // initialize vertex byte buffer for shape
          coordinates (4 bytes per coordinate)
5     ByteBuffer bb = ByteBuffer.allocateDirect(
          triangleCoords.length * 4);
6     // use the device hardware's native byte
          order
7     bb.order(ByteOrder.nativeOrder());
8     // create a floating point buffer
9     vertexBuffer = bb.asFloatBuffer();
10    // add the coordinates to the FloatBuffer
11    vertexBuffer.put(triangleCoords);
12    // set the buffer to read the first
          coordinate
13    vertexBuffer.position(0);
14 }}
```

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Vertex Shader Contains code for rendering the vertices of a shape.

Fragment Shader Contains code for rendering the face (visible front) of shape with colors or textures.

Program OpenGL ES object containing shaders used.

- At least one vertex shader and one fragment shader needed to draw a shape.
- Both shaders must be compiled and then added to the program.

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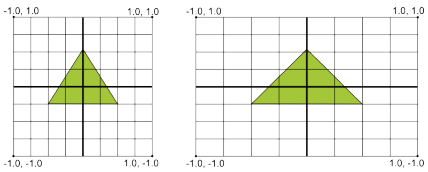
- Problem: Device screen is no square, but OpenGL assumes that[1].
- The picture shows what happens. Left: How it should look. Right: How it looks in horizontal orientation.
- Solution: Use *projection modes* and *camera views* to transform coordinates.



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- Create *projection matrix* and *camera view matrix*.
- Apply both to the OpenGL rendering pipeline.
- Projection matrix recalculates coordinates of the graphic objects to adjust the screen size.
- Camera view matrix creates transformation that shows object from specific eye position.

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Example in OpenGL ES 1.0: Projection Matrix
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- Create and use projection matrix in onSurfaceChanged() of the GLSurfaceView.Renderer implementation.
- Use geometry of device seen to recalculate coordinates.

```
1 public void onSurfaceChanged(GL10 gl, int width
    , int height) {
2   gl.glViewport(0, 0, width, height);
3   float ratio = (float) width / height;
4   // set matrix to projection mode
5   gl.glMatrixMode(GL10.GL_PROJECTION);
6   // reset the matrix to its default state
7   gl.glLoadIdentity();
8   // Define and apply the projection matrix
9   gl.glFrustumf(-ratio, ratio, -1, 1, 3, 7);
10 }
```

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Example in OpenGL ES 1.0: Methods
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- Define a projection matrix in terms of six planes.

```
1 public static void frustumM (float[] m, int
    offset, float left, float right, float
    bottom, float top, float near, float far)
```

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Example in OpenGL ES 1.0: Camera Transformation Matrix
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- Apply camera view in onDrawFrame() of the GLSurfaceView.Renderer implementation.
- Use GLU.gluLookAt() to create a transformation simulating the camera position.

```
1 public void onDrawFrame(GL10 gl) {
2   ...
3   // Set GL_MODELVIEW transformation mode
4   gl.glMatrixMode(GL10.GL_MODELVIEW);
5   // reset the matrix to its default state
6   gl.glLoadIdentity();
7   // When using GL_MODELVIEW, you must set the
      camera view
8   GLU.gluLookAt(gl, 0, 0, -5, 0f, 0f, 0f, 0f,
      1.0f, 0.0f);
9   ...
10 }
```

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Example in OpenGL ES 1.0: Methods
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- Define a transformation in terms of an eye point, a center of view, and an up vector.

```
gluLookAt(GL10 gl, float eyeX, float eyeY,
    float eyeZ, float centerX, float centerY,
    float centerZ, float upX, float upY, float
    upZ)
```


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Displaying Graphics
Example in OpenGL ES 2.0: Steps overview
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1. Define a Projection[5].
2. Define a Camera View.
3. Apply Projection and Camera Transformations on all objects to draw.

- Step 1 and 2 very similar to OpenGL ES 1.0.


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Example in OpenGL ES 2.0: Step 3
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- Apply Projection and Camera Transformations on all objects to draw.
- Edit *draw* method of a shape:

```
public void draw(float[] mvpMatrix) {...
  // get shape's transformation matrix
  matrix = GLES20.glGetUniformLocation(mProgram
      , "uMVPMatrix");
  // Apply projection and view transformation
  GLES20.glUniformMatrix4fv(matrix, 1, false,
      mvpMatrix, 0);
  // Draw the shape
  GLES20.glDrawArrays(GLES20.GL_TRIANGLES, 0,
      vertexCount);
  ...
}
```


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Displaying Graphics
Adding Motion
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- Rotation can be simply added using OpenGL ES 2.0
- Create rotation matrix and combine it with projection and camera view transformation matrices.
- Extend *onDrawFrame* method.


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Displaying Graphics
Adding Motion Example
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```
1 float[] mRotationMatrix = new float[16];
2 // Create a rotation transformation for the
    triangle
3 long time = SystemClock.uptimeMillis() % 4000
    L;
4 float angle = 0.090f * ((int) time);
5 Matrix.setRotateM(mRotationMatrix, 0, mAngle,
     0, 0, -1.0f);
6 // Combine the rotation matrix with the
    projection and camera view
7 Matrix.multiplyMM(mMVPMatrix, 0,
    mRotationMatrix, 0, mMVPMatrix, 0);
8 // Draw shape
9 mTriangle.draw(mMVPMatrix);
```


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Touch Screen Interaction
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- Can be implemented by overriding the method *onTouchEvent(MotionEvent)* of the class *View*.
- *MotionEvent* gives you various information about where the event happened and how.
- Example: *long MotionEvent.getDownTime()* returns the time in ms when user started to press down.
- Also possible to recover *historical*/old coordinates of the event[3].
- Easy simulation in the emulator possible: Click, hold and move the mouse.


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Notes

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- Class *Random* can produce a random number[6].
- Class *Sensor* is used to access sensors of the cellphone, e.g. the gyroscope[8].
- Class *MediaPlayer* enables playing of sounds[2].
- Usage: Put a sound file into folder *res/raw/*.
- Supported file formats include ogg vorbis, wav, mp3 and more.

```
1 MediaPlayer mediaPlayer = MediaPlayer.create(
    context, R.raw.soundfile);
2 mediaPlayer.start();
```

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Summary

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- Drawing with OpenGL takes place on *GLSurfaceView*.
- *GLSurfaceView.Renderer* is responsile to draw the shapes.
- Important to decide which OpenGL ES version to take.
- Shapes are defined using three-dimensional coordinates.
- Different shaders needed to draw a shape.
- *Projection matrix* is used to adjust graphics to the device screen.
- *Camera transformation matrix* is used to simulate a camera position.
- Rotation motion can be added using an additional matrix.
- Touch screen interaction can be implemented overriding method *onTouchEvent*.

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