OpenGL ES CSCI 4239/5239 Advanced Computer Graphics Spring 2023





- OpenGL for Embedded Systems
 - Phones
 - Game consoles
 - Appliances
 - Avionics
 - Subsystems (e.g. browsers)
 - ..
- Cross-platform, open, standard

What is it?

- OpenGL adapted for Embedded Systems
 - Less capable hardware
 - Limited memory
 - Limited processing power
 - Lower clock frequencies
 - Lower power consumption
 - Less heat dissipation
- Same familiar API
 - Subset of full OpenGL API
 - Powerful 3D graphics in your pocket

OpenGL ES Advantages

- Standard and Royalty Free
- Small footprint
- Low power consumption
- Seamless hardware acceleration
- Extensible and evolving
- Easy to use
- Well documented

Current Applications

- Mobile devices
 - iPhone/iPod/iPad
 - Android
- WebGL
 - Chrome, Firefox, Safari, Opera, ...
- Embeded systems
 - 3D displays

OpenGL ES 1.1

- Feature upgrade from OpenGL ES 1.0
- Defined relative to OpenGL 1.5
- Fixed pipeline (no shaders)
- Removes some functionality
 - No glBegin() ... glEnd()
 - Replaced with glDrawArrays() & glDrawElements()
 - No GL_QUAD or GL_POLYGON
 - No display lists
- Still provides lighting, textures, etc.

OpenGL ES 2.0 and later

- Not backwards compatible with ES 1.1
- Defined relative to OpenGL 2.0
- Shaders only (no fixed pipeline)
 - No lighting except in shaders
 - Textures only in shaders
- Removes transformation functions

- No glRotate() glScale() glTranslate()

OpenGL ES 3.0 adds feature upgrades

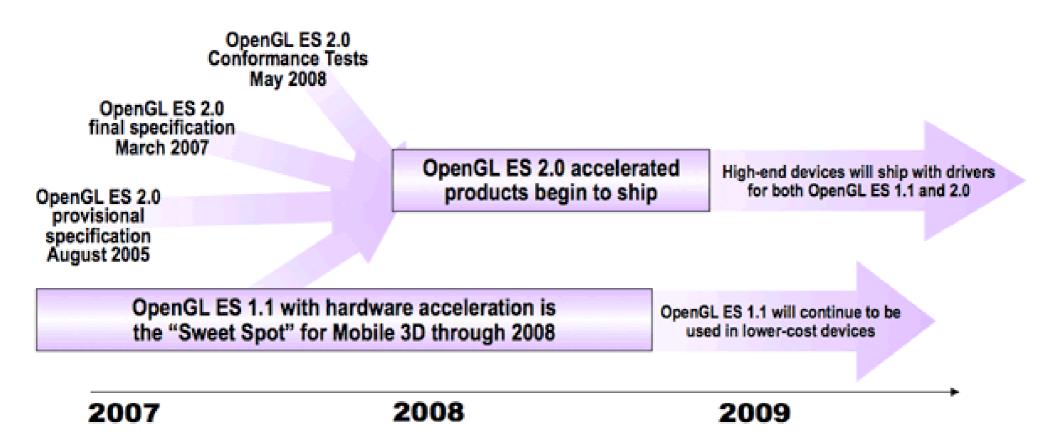
OpenGL ES Evolution

OpenGL ES 2.0 silicon implementations now shipping

- Shader-based graphics comes to mobile
- Conformance tests shipping in May 2008

Listening carefully to implementation and developer feedback

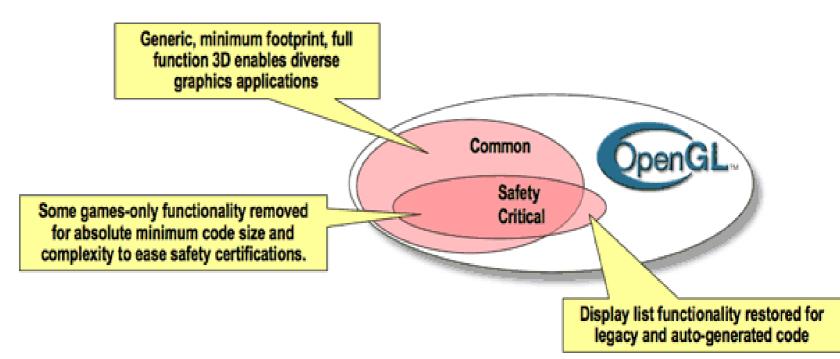
- The determine next-generation requirements



OpenGL SC



- OpenGL for Safety Critical applications
 - Avionics
 - Automotive
 - Industrial
 - Medical
 - Military



OpenGL SC Features

- SC 1.0 starts with OpenGL ES 1.0
 - Adds back some features
 - Begin/End
 - Display Lists
 - Some raster ops
 - Anti-aliasing
 - Removes some features

• Fog

• SC 2.0 starts with OpenGL ES 2.0

WebGL

- OpenGL ES 2.0 for the web
- Extends Javascript
- Operates on HTML5 canvas element
- Prohibits client side arrays
 - All vertex, normal, color, ... must be stored in Vertex Buffer Object on video card
- Becoming more mainstream
 - Still a work in progress

WebGL Platforms

- Supported by most browsers
 - Chromium
 - Firefox
 - Safari
 - Opera
 - Explorer/Edge/...
- Update to recent version
 - Local file access workarounds

Apple iOS Devices

- Supports OpenGL ES 1.1 and 2.0
- User interface is Objective C

- Links to C and C++ code

- Develop with Xcode on Mac only
- Emulator for all devices
 - Slower than native devices
 - Almost perfect emulation
- Apple is replacing OpenGL with Metal

Getting iOS Tools

- Download Xcode from Apple
 - many GB download
- Provides compiler, frameworks, etc
- Create project in Xcode
- Select target iPhone/iPad
- Emulator launched on run
- Get command line tools also

Android Devices

- Supports OpenGL ES 1.1 or 2.0
 - Higher end devices support 1.1 AND 2.0
 - Low end devices may only do 1.1
- User interface is Java
 - Link to C/C++ code with JNI
- Develop with NDK
- Emulator for phones and tablets
 - Slower than native devices
 - Hardware acceleration much improved

Android Tools

- Download Android Studio
 - https://developer.android.com/studio/
 - About 750MB ZIP file
- Unzip and find studio.sh or studio.exe
- Use Configure to download SDK, NDK
- Add Android tools to PATH
 -/SDK/tools
 -/SDK/platform-tools
 -/SDK/ndk-bundle
- Create AVDs

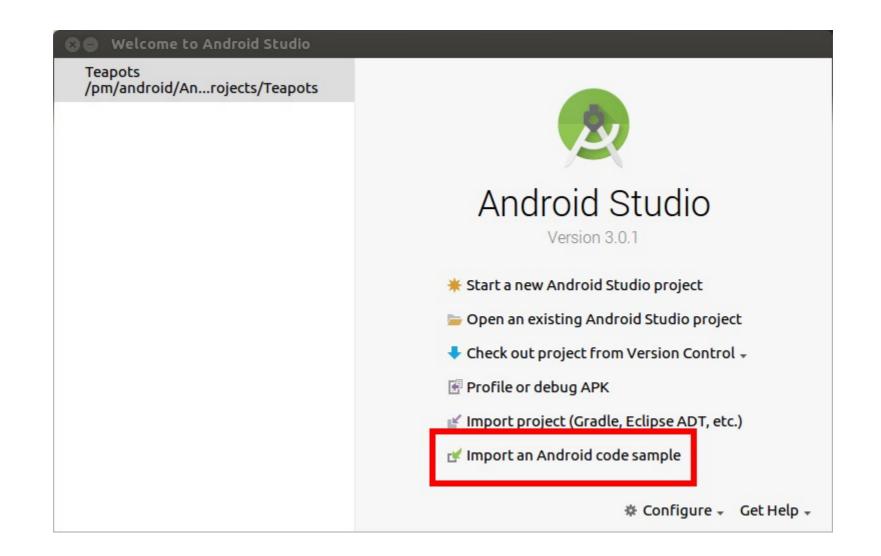
Initial SDK Configuration

Welcome to Android Studio Teapots /pm/android/An...rojects/Teapots Android Studio Version 3.0.1 * Start a new Android Studio project Dpen an existing Android Studio project Check out project from Version Control + Profile or debug APK Import project (Gradle, Eclipse ADT, etc.) Import an Android code sample & Configure -Get Help 🚽

Select and install SDK Tools

	Appearance & Behavior > System Settings > Android SDK		
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Appearance	Android SDK Location: /pm/android/SDK	Edi	t
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Passwords	Below are the available SDK developer tools. Once installed, automatically check for updates. Check "show package deta		
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HTTP Proxy	Name	Version	Status
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Notifications	Android Auto API Simulators	1	Not installed
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Plugins	Google Play Licensing Library	1	Notinstalled
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Import Code Example



Teapots NDK/OpenGL ES 2.0

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Import Sample



Browse Samples Android Studio

Select a sample to import

Q- Tea ▼ Android o preview

Downloadable Fonts (Kotlin)

- Connectivity
 Beam Large Files
- Content

Scoped Directory Access

Getting started

Wear Verify Remote App

Ndk

Teapots

V UI

Downloadable Fonts Downloadable Fonts (Kotlin) Wear Verify Remote App Teapots is an collection of Android C++ samples that uses a Teapot rendering to demostrate Android NDK platform features: - classic-teapot: Rendering classic teapot mesh using GLES 2.0 API and <u>NativeActivity</u>. - more-teapots: Rendering multiple instances of Classic Teapot with GLES 3.0 Instance Rendering - Choreographer-30fps: demonstrates multiple frame rate throttoling techniques based on API level using Chreographer API and EGL Android presentation time extension. This sample uses the new Android Studio CMake plugin with C++ support.

Tags: ndk

Browse source in GitHub

60.10 FPS

Previous Next

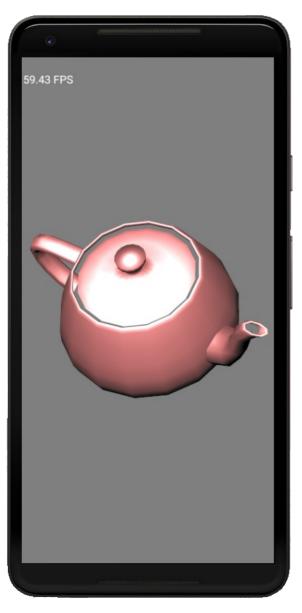
Select Target, Build and Run

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Create Virtual Device using Wizard

8 Select Deployment Target			
Connected Devices			
📕 Pixel 2 XL API 27 (Android 8.1.0, API 27)			
Create New Virtual Device			
	ОК	Cancel	Help

teapot, textured-teapot and more-teapots







Portable OpenGL ES Code

- Write the bulk of the code in C++
 - OpenGL ES 1.1 will run on all devices
 - OpenGL ES 2.0 will run on higer end devices
- Write minimal code in interface language
 - Objective C link to C/C++
 - Java call C/C++ using JNI
- Qt 5 for iOS/Qt 5 for Android
 - Later builds are better

Assignment 5

- Create a scene that can be viewed in 3D using WebGL or IOS or Android
 - Must support lighting and textures
 - Objects must be created in code
 - I want you to get some experience using vertex buffer objects
 - WebGL may use mat4.js or CanvasMatrix library, but NOT Three.js or similar high level libraries
- Explore features like buttons