

# Computer Graphics and GPGPU Programming

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# Course Introduction

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- Master degree course in Computer Science
  - *Artificial Intelligence and Games* profile
  - *Scientific Computing* profile
- Main topics
  - **Computer Graphics programming** in OpenGL core profile
  - **GPGPU programming** in OpenCL and/or CUDA
- Prerequisites: basic level C++ programming
- Suggested resources/textbooks
  - Learn OpenGL <http://learnopengl.com/>
  - *OpenGL SuperBible Sixth Edition*, Graham Sellers et al., Addison-Wesley
  - *OpenCL in Action*, Matthew Scarpino, Manning

# Course Introduction

- Further readings
  - OpenGL Programming Guide Eighth Edition, Dave Shreiner et al., Addison-Wesley
  - 3D Computer Graphics, Alan Watt, Pearson, Addison-Wesley
  - NVIDIA CUDA C Programming Guide  
`developer.download.nvidia.com/compute/cuda`
- Exam
  - Written examination (about 10 questions on Computer Graphics and GPGPU computing)
  - Student project (a 3D Computer Graphics project in OpenGL core profile)
- Office ours: Tuesday, from 17:00 to 18:00, Cubo 22B (in case of special needs, send me an email)

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# OpenGL core and compatibility profile



- OpenGL is a standard API defined by Khronos Group that applications can use to access and control the graphics subsystem (i.e. the Graphics Processing Unit, or GPU)
- Originally developed by Silicon Graphics (SGI), the first open (1.0) version was released in June of 1992
- In 2008, with the 3.3 specification, the Architecture Review Board (ARB) decided it would fork OpenGL into two profiles: core (strongly recommended) and compatibility

# OpenGL core and compatibility profile

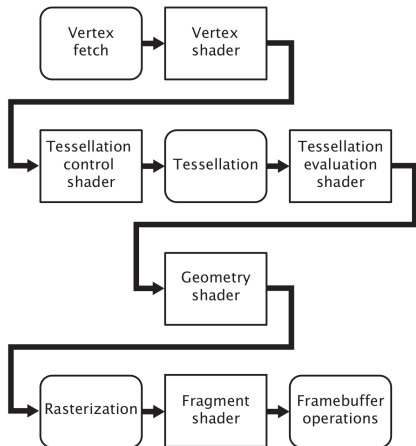


- The compatibility profile maintains backwards compatibility with all revisions of OpenGL back to version 1.0
- On some platforms, newer features are only available if you are using the core profile of OpenGL
- Application written using the core profile of OpenGL will run faster



# OpenGL Shaders and the Graphics Pipeline

- The graphics system is broken into a number of stages, each represented either by a programmable **shader** (square boxes) or by a fixed-function (rounded boxes)
- The minimal useful pipeline configuration consists only of a **vertex shader** (or just a compute shader), but if you wish to see any pixels on the screen, you will also need a **fragment shader**

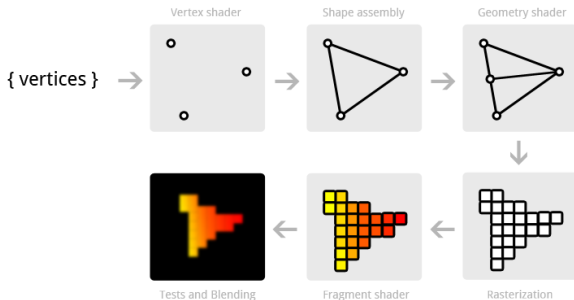


# Graphics Pipeline's Front and Back End

- The graphics pipeline is broken down into two major parts
- The first part, often known as the **front end**, is constituted by the vertex, tessellation and geometry shaders and processes vertices and primitives, eventually forming them into the points, lines, and triangles that will be handed off to the rasterizer. This is known as primitive assembly
- After the rasterizer, the geometry has been converted from what is essentially a vector representation into a large number of independent pixels
- These pixels are handed off to the **back end**, which includes depth and stencil testing, fragment shading, blending, and updating the output image

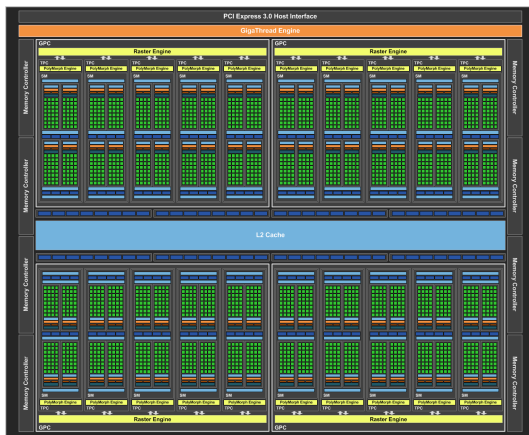
# Primitives, Pipelines, and Pixels

- The fundamental unit of rendering in OpenGL is known as the primitive (such as points, lines, triangles and polygons)
- Each primitive is basically defined by its **verteices**, each one defining information about a point into the 3D world such as position, color, besides other (that we will see later), and then processed by the OpenGL pipeline to produce the final image



# Rasterizers (GPUs)

- Modern GPUs consist of thousands of small programmable processors called **shader cores** which run mini-programs called **shaders**



# Rasterizers (GPUs)

- Here you can find Nvidia GTX 1080 tech specs:  
[http://international.download.nvidia.com/geforce-com/international/pdfs/GeForce\\_GTX\\_1080\\_Whitepaper\\_FINAL.pdf](http://international.download.nvidia.com/geforce-com/international/pdfs/GeForce_GTX_1080_Whitepaper_FINAL.pdf)
- For instance, vertices are processed (for instance, each of them is translated from its current position to another one into the 3D space) in parallel, each one by a different shader core
- There is no interaction between them, so that they can be processed concurrently without the need of inter communication among shader cores
- However, since OpenGL acts as an abstraction layer, applications do not need to know details about the graphics processor: who made it, how many cores it is made by, how it works, or how well it performs

# Practice

- Now, it's time to draw your first triangle



- For this purpose, we will consider the GLFW and GLEW APIs and CMake to build our projects
- Later, we will introduce other libs, e.g. GLM (for math purposes)



- Please, refer Chapters 2, 3 and 4 from the Learn OpenGL tutorial and example codes from the course web site

# Homework



- Please, take a look to Chapters 6 and 7 of the LearnOpenGL tutorial about Shaders and Textures