Liverpool John Moores University

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Title:	REAL-TIME RENDERING
Status:	Definitive
Code:	**6107COMP** (121266)
Version Start Date:	01-08-2021
Owning School/Faculty:	Computer Science and Mathematics
Teaching School/Faculty:	Computer Science and Mathematics

Team	Leader
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Academic Level:	FHEQ6	**Credit Value:**	20	**Total Delivered Hours:**	56.5
Total Learning Hours:	200	**Private Study:**	143.5		

Delivery Options
Course typically offered: Semester 2

Component	Contact Hours
Lecture	22
Practical	33

Grading Basis: 40 %

Assessment Details

Category	Short Description	Description	Weighting (%)	Exam Duration
Artefacts	AS1	Real-time rendering of procedurally generated complex virtual worlds.	60	
Exam	AS2	Examination.	40	1.5

Aims

To describe the architecture of graphics hardware and processing unit.
To explain the interaction between a graphics API, its shader and compute language and the GPU architecture.

To explain the principles of advanced computer graphics processes across the various stages of the programmable rendering pipeline.
To compare and contrast algorithms used to model key aspects of photo realism in real-time.
To outline the mathematical models used to represent visual phenomena such as light, colour, shadow, reflection in real-time.
To illustrate how post processing techniques can be used to simulate cinematographic effects in real-time.
To develop skills in advanced computer graphics operations using a modern graphical API and its shader/compute system.

Learning Outcomes

After completing the module the student should be able to:

1	Critically evaluate the state-of-art graphics processes employed in modern games development.
2	Critically analyse GPU architecture and how it affects program design.
3	Construct complex geometrical shapes procedurally using relevant algorithms.
4	Apply advanced computer graphics algorithms and processes to speed up rendering process.
5	Apply advanced shader techniques to produce high quality rendering of complex scenery.

Learning Outcomes of Assessments

The assessment item list is assessed via the learning outcomes listed:

Real-Time Rendering	3	4	5
Examination	1	2	

Outline Syllabus

GPU architecture and shader
- Processor Architectures.
- GPU vs. CPU.
- How shader code is executed by a GPU.

Evolution and History of Shader Models
- Vertex and Pixel Shaders.
- Geometry Shader.
- Hull and Domain Shaders.
- Compute Shaders for Graphics.

Geometry
- Geometric operations such as intersection calculation and proximity tests.
- Volumes, voxels, and point-based representations.
- Parametric polynomial curves and surfaces.

- Approximation techniques such as polynomial curves, Bezier curves, spline curves and surfaces, and non- uniform rational basis (NURB) spines, and level set method.
- Dynamic level of detail.

Procedural Content Generation:
- Pseudo Random Number Generation.
- Perlin noise.
- Terrain Generation.
- Fractals / Function driven procedurals.
- Data Driven vs Pure Procedural.
- Water, Particles.
- Fluid Rendering in Real-Time.
- Blocks and Voxels.

Culling techniques
- Surface culling (front face, back face).
- Occlusion culling.

Rendering techniques
- Multiple light sources.
- Forward Rendering vs. Light Pre Pass vs Deferred Rendering.
- Physically Based Rendering – BSDF, BRDF.
- Pre-Computed Radiance Transfer (PRT).
- Advanced Texture Mapping: Bump mapping/Normal Mapping/Parallax Occlusion Mapping.
- Volumetric Lighting.
- Global Illumination in Real-Time: Reflection/Refraction/Shadow mapping/Light Mapping (Baked Lighting).

Image-based effects and post processing
- Spatial / Temporal Blur.
- Depth of field / Bokeh.
- Bloom
- Ambient Occlusion
- Non-photorealistic effects

Output Merger Optimisations
- Sample Based
- Morphological Anti-Aliasing

Learning Activities

Lectures – to deliver the theoretical concepts on real-time rendering with demonstration.
Practical – Tutor-led practical session in the computer laboratory.
Further exercises – additional exercises for students to work on in their own time.
Directed learning – provides additional reading to enable practical work to be completed.

Learning materials can be accessed digitally via University Virtual Learning Environment (VLE).

Notes

This module builds on the students' knowledge of the principles of 3D graphics and furthers their understanding of advanced computer graphics processes. The module uses a modern GPU-driven graphics API to demonstrate how complex 3D scenes can be constructed from complex geometry and rendered in real-time with special effects. Focuses on the state of the art approaches to real-time rendering and how graphics programmmers are targeting the goal of photorealistic rendering in real-time.