Module Proforma

Approved, 2022.02

Summary Information

Module Code	7149COMP
Formal Module Title	Virtual Worlds for Shared Space Technologies
Owning School	Computer Science and Mathematics
Career	Postgraduate Taught
Credits	20
Academic level	FHEQ Level 7
Grading Schema	50

Module Contacts

Module Leader

Contact Name	Applies to all offerings	Offerings
Yann Savoye	Yes	N/A

Module Team Member

Contact Name	Applies to all offerings	Offerings

Partner Module Team

Contact Name	Applies to all offerings	Offerings

Teaching Responsibility

LJMU Schools involved in Delivery
Computer Science and Mathematics

Learning Methods

Learning Method Type	Hours

Lecture	11
Workshop	22

Module Offering(s)

Offering Code	Location	Start Month	Duration
SEP-CTY	CTY	September	12 Weeks

Aims and Outcomes

Aims	• To explain the digital content creation workflow for Virtual World construction • To develop theoretical knowledge of the concepts and techniques required for 3D modelling and design of Virtual Worlds. • To provide students an opportunity to practice the principles of 3D modelling Virtual World construction using appropriate tools, techniques and methods.• To explain the fundamental mathematical principles of 3D computer graphics 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 and how they apply to material systems.

Learning Outcomes

After completing the module the student should be able to:

Code	Description
MLO1	Demonstrate a deep and systemic understanding of the fundamental techniques underpinning virtual world construction and scene composition.
MLO2	Compose 3D scenes using real-time rendering technique for complex 3D geometry using both physically based global illumination schemes.
MLO3	Make informed and critical decisions regarding the visual material schemes, cinematographic effects and lighting to construct a believable, immersive virtual space.
MLO4	Critically evaluate the state-of-art graphics processes employed in modern Virtual Reality and Augmented Reality development.
MLO5	Solve complex problems in 3D graphics and VR and AR using appropriate mathematical concepts.

Module Content

Outline Syllabus

Mathematical principles: - Linear Algebra: Mathematical and geometric definitions of vector, Vectors vs. Points, Vector additions, subtraction, and multiplications, Vector dot product and cross product, unit vector, Transforms and Matrices. Applying these concepts in 3D space.- 3D Coordinate space: Euclidean Geometry, 3D Cartesian Coordinates. Affine and coordinate system transformations.- Theory of rotation in 3D and its implementation: Euler Angle, Tait-Bryan, Axis-Angleand Quaternion (including Complex Numbers).- Normal vector calculations.Theory of viewing and projection in 3D and their implementation:- View Matrix- Orthographic and Perspective Projection.- Projection matrix.Introduction to Programmable Graphics Pipeline using GPU Shaders:- Pipeline Stages.- Local, World, View and Screen Spaces.Polygonal representation:- Polygon Meshes: Vertices, Edge and Faces, Graphics primitives, Indexed trianglemesh, surface normal. Buffer formations and TopologiesSurface representation techniques including tessellation, mesh representation, mesh fairing such as Delaunay triangulation, marching cubes.- DCC (Digital Content Creation) Content Importing and Data Parsing for PolygonalMeshes and Texture/Buffer Resources:- Texture mapping, including - Diffuse, Specular and Normal mapping.- Texture mapping implementation using shaders.Illumination and shading model including:- Rendering in nature: Introduction to Physically Based Lighting.- Local Illumination vs. Global Illumination– Indirect vs. Direct Lighting.- Simple BRDF-based lighting techniques.- Light sources: Point vs Area-Based light sources.- Local illumination implementation using shaders.Level Design and Use of 3D Assets:Digital Game Content Creation Pipeline: Game Production Timeline, Roles in the Game Production Team Optimization PipelineContent Importing/Exporting and Asset Management Low vs High Poly Modelling Techniques3D Virtual Scene Composition: Asset planning, Reusing assets, Level of Detail (LoD), Procedural Level Generation.Indoor and Outdoor Scenes3D Cameras and Cinematographic Concepts. Scene Organization, Hierarchies and Relationships between different objects.Compositing Scenes and Layering. Materials: PBR Materials and High-End Product Lighting and RenderingMaterial Systems and their link to GPU ShadersMaterial ToolsetsPost Processing materials Pre-Computed Lighting, Precomputed Radiance Transfer (PRT) for Baked Lighting

Module Overview

This module teaches fundamental mathematical techniques such as numerical calculus, analytical geometry, linear algebra and angular concepts, with a focus on practically constructing three-dimensional virtual worlds. Industry standard Digital Content Creation tools and game engine level editing software are used, mathematical concepts of translation, rotation and scaling to 3D Meshes are applied and materials, post processing, camera and scene construction techniques are used to build immersive, believable virtual spaces for use with the shared space technologies.

Additional Information

This module teaches students the fundamental mathematical techniques such as numerical calculus, analytical geometry, linear algebra and angular concepts, with a focus on practically constructing three-dimensional virtual worlds using industry standard Digital Content Creation tools and game engine level editing software, applying the mathematical concepts of translation, rotation and scaling to 3D Meshes and using materials, post processing, camera and scene construction techniques to build immersive, believable virtual spaces for use with the shared space technologies.

Assessments

Assignment Category	Assessment Name	Weight	Exam/Test Length (hours)	Learning Outcome Mapping

Technology	Virtual World Construction	60	0	MLO3, MLO2, MLO1
Centralised Exam	Exam	40	1.5	MLO4, MLO5