Title (Units): **COMP4025 AI-Enabled Interactive Computer Graphics (3,2,2)**

Course Aims: Students will learn (i) the mathematical foundations and algorithms essential for modern computer-graphics systems—including geometric transformations, rendering techniques, and interactive methods—(ii) the principles and tools that enable human-object interaction in virtual environments, and (iii) AI-driven generative methods for creating geometry, textures, relighting, and video effects that augment the classical pipeline. Through hands-on practice with graphics APIs and pretrained neural models, students will gain practical experience by creating a prototype application that blends classical rendering with generative-AI content creation.

Prerequisite: COMP3057 Introduction to AI and ML OR COMP3117 Applied Artificial Intelligence

Course Intended Learning Outcomes (CILOs):
Upon successful completion of this course, students should be able to:

No.	Course Intended Learning Outcomes (CILOs)
	Knowledge
1	Describe the complete workflow for constructing a computer graphics system.
2	Explain and analyse the theory and algorithms for 3D geometric transformation, projection, and rendering.
3	Explain and evaluate the principles behind AI-driven generative models for geometry, texture modelling, and relighting.
4	Explain the principles and algorithms in computer vision and graphics that enable human–object interaction in virtual environments.
	Professional Skill
5	Design and integrate generative-AI techniques within the graphics pipeline
6	Develop a complete graphics application using a graphics programming interface

Calendar Description: Students will learn (i) the mathematical foundation and algorithms for creating computer graphics including transformation, rendering, and (ii) the algorithms for enabling Human-Object interaction in virtual environment. Students will also gain practical experience on these topics by using graphics application programming interface (API) and develop a graStudents will learn the mathematical foundations and core algorithms of interactive computer graphics and extends them with modern AI-based generative techniques. Students explore geometric transformations, shading, and rendering; learn vision-driven methods for human-object interaction; and investigate generative models for generating geometry, textures, relighting, and video effects. Through hands-on labs using industry-standard graphics APIs and pretrained neural frameworks, students will gain practical experience by creating a prototype application that blends classical rendering with generative-AI content creation.phics application prototype.

Teaching and Learning Activities (TLAs):

CILOs	Type of TLA
1-4	Students will learn the principles and algorithms of computer graphics and new generative approaches that enhance conventional ones through lectures.
1-6	Students will gain hands-on experience and deepen their understanding of the underlying principles and algorithms through weekly laboratory sessions, targeted lab exercises, and assignments. Labs cover practical computer-graphics programming with industry APIs and guided experiments that apply generative approaches to accelerate and enhance conventional workflows.
5,6	Students will apply and integrate the learnt algorithms, with their new ideas for developing an interactive graphics application through group project.

Assessment:

No.	Assessment Methods	Weighting	CILOs to be addressed	Description of Assessment Tasks
1	Quiz and/or Written Assignments	20%	1-4	Written assignment(s) and/or in-class quiz will be arranged to monitor student's ongoing performance throughout the course.
2	Lab Exercises	10%	5,6	Weekly lab exercise will be arranged to help students to employ the skills they've learned, improving problem-solving, comprehension, and critical thinking.
3	Collaborative Group Project	30%	5,6	Students are required to work in small groups to create a complete graphics application with graphics APIs and integrate generative-AI techniques.
4	Examination	40%	1-6	The final examination is designed to evaluate students' understanding in different parts. The questions will include fundamental, analytic and design types in order to distinguish different levels of understanding of computer graphics.

Assessment Rubrics:

Excellent (A)	• Achieve the first four CILOs, demonstrating a good mastery of both the theoretical and practical aspects of computer graphics. • Demonstrate a thorough understanding of the mathematics in computer graphics by developing complicated 3D interactive graphics using a series of transformation and viewing matrices. • Able to develop 3D computer graphics with realistic lighting and texturing effects, and pay sufficient considerations in their computational complexities. • Able to integrate generative-AI components to improve and extend traditional graphics pipelines. • Demonstrate an excellent self-learning capability by bringing new techniques into the group project.
Good (B)	• Achieve the first four CILOs, demonstrating a good understanding of the concepts involved in computer graphics. • Demonstrate a good understanding of the mathematics in computer graphics by developing basic 3D interactive graphics using a couple of transformation and viewing matrices. • Able to develop 3D computer graphics with realistic lighting and texturing effects, but lack sufficient considerations in their computational complexities. • Able to integrate generative-AI components and achieve satisfactory visual realism. • Demonstrate a good self-learning capability by bringing new techniques into the group project.
Satisfactory (C)	• Achieve the first four CILOs, demonstrating a basic level of understanding of the concepts in computer graphics. • Demonstrate a basic understanding of the mathematics in computer graphics by developing basic 3D interactive graphics using a couple of transformation and viewing matrices. • Able to develop 3D computer graphics with not-so-realistic lighting and texturing effects, and lack sufficient considerations in their computational complexities. • Able to integrate generative-AI components but cannot achieve satisfactory visual results as compared to conventional approaches. • Rely on the given laboratory materials to complete the group project.
Marginal Pass (D)	• Achieve the first four CILOs, demonstrating a minimal level of understanding of the concepts involved in computer graphics. • Have a limited understanding of the mathematics in computer graphics.

Fail (F)	• Able to develop 3D computer graphics with not-so-realistic lighting and texturing effects, and lack any considerations in their computational complexities. • Able to integrate generative-AI components but cannot achieve convincing visual results as compared to conventional approaches. • Rely heavily on the given laboratory materials to complete the group project. • Achieve less than four of the CILOs, and have little understanding of the concepts involved in computer graphics. • Unable to develop basic 3D interactive graphics using transformation and viewing matrices • Unable to apply lighting and texturing effects. • Unable to integrate generative-AI components. • Do not complete the group project.

Course Content and CILOs Mapping:

Content		**CILO No.**
I	Module A Computer Graphics Foundations (7 weeks) Computer Graphics Pipeline & Shaders	1, 6
II	Lighting & Shading	2, 6
III	Geometry and Transforms	2, 6
IV	Projection, Clipping, and Rasterization	1,2,6
V	Advanced Rendering	1,2,6
VI	Module B AI-Enabled Advancements Generative Frameworks for Geometry & Texture	2,3,5,6
VII	AI-Driven Multiview Reconstruction & Relighting	2,3,5,6
VIII	Generative Visual Effects (VFX) with Vision Foundation Models	3,5,6
IX	Module C Interaction Techniques (2 weeks) Motion Capture and Animation	4,5,6
X	AR/VR Algorithms and Applications	4,5,6

References:

• F. Ganovelli, M. Corsini, S. Pattanaik, M. Di Benedetto, Introduction to Computer Graphics: A Practical Learning Approach, CRC Press, 2014.
• Edward Angel and Dave Shreiner, Interactive Computer Graphics with WebGL, 7th edition, Addison Wesley, 2014.
• Steven J. Gortler, Foundations of 3D Computer Graphics, The MIT Press, 2012.
• Jos Dirksen, Three.js Cookbook, Packt Publishing, 2015.
• Edward Angel and Dave Shreiner, Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL, 8th Edition, Pearson, 2020.
• Lee Stemkoski and James Cona, Developing Graphics Frameworks with Java and OpenGL, CRC Press, 2022.
• Ke Zhao and Andreas Larsen, Challenges and Opportunities in 3D Content Generation, arXiv preprint arXiv:2405.15335, 2024.
• J. Liu, X. Huang, T. Huang, L. Chen, Y. Hou, S. Tang, Z. Liu, W. Ouyang, W. Zuo, J. Jiang and X. Liu, A Comprehensive Survey on 3D Content Generation, arXiv preprint arXiv:2402.01166, 2024
• F. Tosi, Y. Zhang, Z. Gong, E. Sandström, S. Mattoccia, M.R. Oswald and M. Poggi, How NeRFs and 3D Gaussian Splatting Are Reshaping Slam: A Survey. arXiv preprint arXiv:2402.13255, 4, p.1., 2024
• Diffusion-based Video Generative Models, CVPR 2024 Tutorial on Diffusion-based Video Generative Models. [Online]. Available: https://showlab.github.io/cvpr2024-tutorial-video-diffusion-models/.
• Selective reading from recent issues of IEEE Transactions on Pattern Analysis and Machine Intelligence, ACM Transaction on Graphics, Proceedings of SIGGRAPH, SIGGRAPH Aisa, CVPR, ICCV, ECCV, et

Course Content:

Topic

I. Module A Computer Graphics Foundations (7 weeks) Computer Graphics Pipeline & Shaders
- Graphics pipeline;
- Programmable shaders;
- GPU

II. Lighting & Shading
- Phong/Blinn reflection models;
- Normal; basic texture sampling

III. Geometry and Transforms
- Vectors/matrices, 2D/3D Transformations
- Curves and surfaces

IV. Projection, Clipping, and Rasterization
- Projection, clipping, rasterization basics

V. Advanced Rendering
- Global illumination, ray tracing

VI. Module B AI-Enabled Advancements Generative Frameworks for Geometry & Texture
- Diffusion/GAN pipelines; text-to-texture; 3D asset generation

VII. AI-Driven Multiview Reconstruction & Relighting
- Neural radiance fields (NeRF); 3D Gaussian Splatting;
- AI for relighting

VIII. Generative Visual Effects (VFX) with Vision Foundation Models
- Text/image-to-video diffusion;
- ControlNet; special effects

IX. Module C Interaction Techniques (2 weeks) Motion Capture and Animation
- Vision-based tracking, rigging, retargeting, and animation
- Hierarchical modelling

X. AR/VR Algorithms and Applications
- VR/AR basics and applications
- Metaverse concepts and applications