

COMPUTER GRAPHICS (CCG3013)

LESSON 11

LIGHTING AND RENDERING



COURSE OUTLINE

Lesson	Topic
1	Introduction to computer graphics
2	Graphics hardware and software
3	Geometry in 2D graphics
4 & 5	Geometry in 3D graphics
6 & 7	User interfaces and interactions
8	Colour
9	Lighting and rendering
10 & 11	Motion and animation
12	Surface shadings

ASSESSMENTS

Structure	Marks (%)	Hand-out	Hand-in
Assignment 1	30	RELEASED	DUE
Assignment 2	30	RELEASED	Week 12
Final Examination	40	Exam Week	

LEARNING OUTCOMES

1. Describe Phong's reflection model.
2. Describe ray casting techniques.
3. Explain and implement lighting functions.

CONTENT

No.	Topics	Duration (Minutes)
1	Mini lecture 1: Light sources	15
2	Exercise 1	10
3	Mini lecture 2: Phong's reflection model	15
4	Exercise 2	10
5	Break	10
6	Mini lecture 3: Ray casting techniques	15
7	Exercise 3	10
8	Mini lecture 4: Lighting functions in OpenGL	15
9	Exercise 4	10

MINI LECTURE 1

LIGHT SOURCES

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LIGHTINGS

1. It lights up the world.
2. There are two types of lightings; **Global lightings** and **local lightings**.
3. Lighting parameters included, **location of the source**, **intensity**, **colour**, **shadow casting**, **attenuation**, and **location of the target**.

GLOBAL LIGHTINGS

1. An **Omni light** that has radian which is exceeded the world to be illuminated.
2. Commonly it is used to simulate sunlight, e.g.
 - (a) Well lit environment to simulate **daytime**.
 - (b) Dim lit environment to simulate **night time**.

LOCAL LIGHTINGS

1. **Point light** that emits ray particles in a sphere (e.g. light bulb, emergency light, candle light, beacon of a buoy, LED, chandelier, etc.)
2. **Directional light** that emits ray particles at a direction (e.g. table lamp, car light, laser, etc.)
3. **Spot light** that emits ray particles in a cone (e.g. torch light, spot light in a stadium, spot light in a concert, spot light from a lighthouse, etc.)
4. **Area light** that emits ray particles in a pyramid (e.g. fluorescent light, light pole, projector light, etc.)
5. **Ambient light** that emits ray particles and illuminated from a surface, such as a wall. (e.g. show rooms)

EXERCISE 1 (10 MINUTES)

This activity will takes about 10 minutes.

1. State and explain the parameters of a lighting.



2. What is the lighting used for global lighting?

3. What are the lightings used for local lighting?

MINI LECTURE 2

PHONG'S REFLECTION MODEL

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PHONG'S REFLECTION MODEL

1. It is an **illumination model**, which is developed by **Bui Tuong Phong** in **University of Utah**.
2. There are four direction vectors to compute an overview of a 3D model; **light that is opposite of the light source**, **specular highlight**, **surface normal**, **reflectional light**.
3. It has three important channels, which are **diffuse**, **specular**, and **ambient**.

CHANNELS IN PHONG'S SHADER

Channels	Description
Diffuse	It represents the colour or texture map for the surface of an object.
Specular	The amount of light bouncing off at the corners of a surface.
Reflection	It is the mirror effect from the environment.
Ambient occlusion	It adds darkness to the outer surfaces of an object.

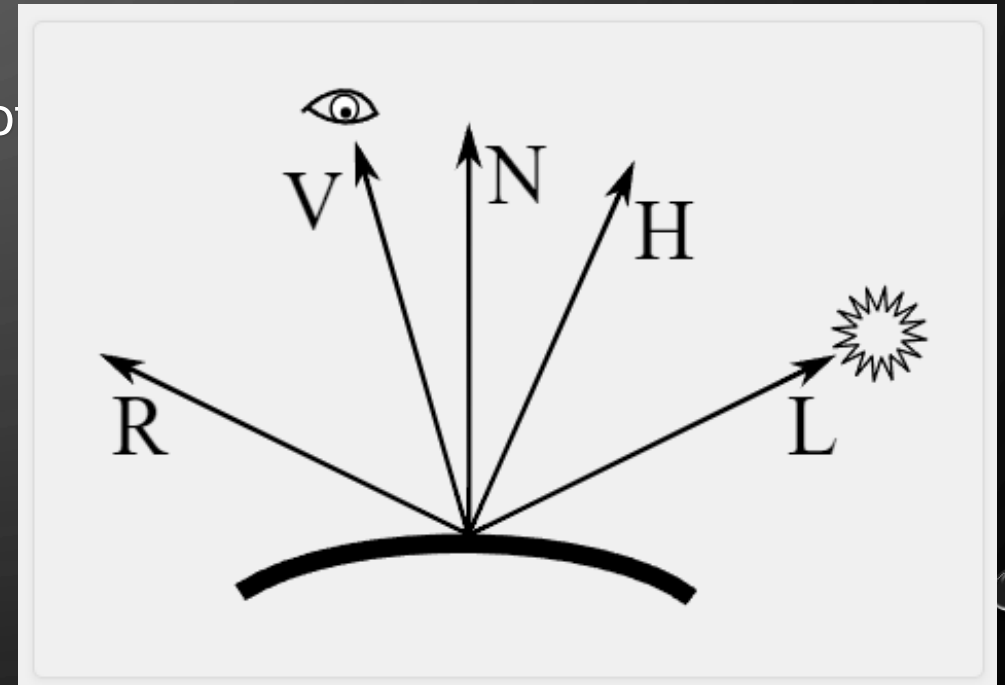
EXERCISE 2

This activity will takes about 10 minutes.



1. Illustrate five direction vectors demonstrated by Phong.

2. State and explain three main channels of



BREAK

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MINI LECTURE 3

RAY CASTING TECHNIQUES

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RAY CASTING

1. It is a computation of light from the **observer** or viewer to the **target surfaces of 3D models**.
2. Computations of ray casting included
 - (a) **Interpolation** of a ray from observer to the first intersect surface.
 - (b) **Remove hidden surfaces** which is not within the area of viewing from the observer.
 - (c) **Estimate depth** of 3D models using volume ray tracing.

EXERCISE 3

This activity will takes about 10 minutes.

1. Identify three ray casting applications used in the 3D rendering software.
2. Explain these applications in terms of the features and its computations for rendering.



MINI LECTURE 4

LIGHTING FUNCTIONS IN OPENGL

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LIGHTING FUNCTION

Function name	glLightfv, glLightxv
Purpose	Set light source. At least 8 lights are supported.
Arguments or parameters	GLenum light, it can be sorted from GL_LIGHT0 to GL_MAX_LIGHTS-1; GLenum pname, mode of lighting; GLfloat parameter, parameter for a selected mode;
Return value	None.

MODES FOR PNAME

GL_DIFFUSE

GL_SPECULAR

GL_AMBIENT

GL_POSITION

GL_SPOT_DIRECTION

GL_SPOT_EXPONENT

GL_SPOT_CUTOFF

GL_CONSTANT_ATTENUATION

GL_LINEAR_ATTENUATION

GL_QUADRATIC_ATTENUATION

EXERCISE 4

This activity will takes about 10 minutes.

Identify the initial values for GL_DIFFUSE, GL_SPECULAR, and GL_AMBIENT modes.

EXERCISE 4 SOLUTIONS

Identify the initial values for GL_DIFFUSE, GL_SPECULAR, and GL_AMBIENT modes.

Mode of lightings	Initial values
GL_DIFFUSE	(1, 1, 1, 1) for GL_LIGHT0, while (0, 0, 0, 1) for others.
GL_SPECULAR	((1, 1, 1, 1) for GL_LIGHT0, while (0, 0, 0, 1) for others.
GL_AMBIENT	(0, 0, 0, 1)

REFERENCES

Main reference:

Hajek, D. (2019). Introduction to Computer Graphics 2019 Edition. Independently Published.

Additional reference:

Marschner, S. and Shirley, P. (2021). Fundamentals of Computer Graphics, 5th Edn. CRC Press: Taylor's & Francis.