Smart House Weather Simulation using OpenGL

Submitted By

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MINI LAB PROJECT REPORT

This Report Presented in Partial Fulfillment of the course **CSE412: Computer Graphics Lab in the Computer Science and Engineering Department**

DAFFODIL INTERNATIONAL UNIVERSITY

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DECLARATION

We hereby declare that this lab project has been done by us under the supervision of **Nawshin Haque**, **Lecturer**, Department of Computer Science and Engineering, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere as lab projects.

Submitted To:

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COURSE & PROGRAM OUTCOME

The following course have course outcomes as following:.

Table 1: Course Outcome Statements

CO's	Statements
CO1	**Define** and **Relate** shape, objects, 2D implementation and relationships among them needed for solving specific problems
CO2	**Formulate** knowledge of C++ programming and OpenGL in problem solving
CO3	**Analyze** 2D to **Present** a specific problem
CO4	**Develop** solutions for real-world complex problems **applying** computer graphics concepts while evaluating their effectiveness based on industry standards.

Table 2: Mapping of CO, PO, Blooms, KP and CEP

CO	PO	Blooms	KP	CEP
CO1	PO1	C1, C2	KP3	EP1, EP3
CO2	PO2	C2	KP3	EP1, EP3
CO3	PO3	C4, A1	KP3	EP1, EP2
CO4	PO3	C3, C6, A3, P3	KP4	EP1, EP3

The mapping justification of this table is provided in section **4.3.1**, **4.3.2** and **4.3.3**.

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Chapter 1: Introduction

1.1 Introduction

Computer Graphics plays a vital role in creating interactive visual systems that simulate real-world environments. With the advancement of graphical libraries such as OpenGL, it has become easier to design dynamic and responsive visual applications.

This project, titled **"Smart House Weather Simulation Using OpenGL"**, focuses on developing a 2D graphical simulation of a smart house environment where different weather conditions can be controlled interactively. The system allows users to simulate rain, cloudy sky, and normal weather conditions using keyboard inputs, while also enabling day and night transitions through mouse interactions.

The project demonstrates how graphical primitives, animation techniques, and user input handling can be combined to create a realistic and educational simulation environment.

1.2 Motivation

The motivation behind this project comes from the need to understand how real-time environmental changes can be simulated using computer graphics.

Many beginner-level graphics projects focus only on static scenes, which do not reflect real-world dynamics. This project aims to overcome that limitation by introducing interactive weather control and lighting changes.

Key motivational points include:

a) To move beyond static graphical designs
b) To explore real-time simulation concepts
c) To understand user interaction in graphical systems
d) To create a visually meaningful and educational project

1.3 Objectives

The main objective of this project is to design and implement a smart house simulation that supports multiple weather conditions and interactive controls.

Specific objectives:

a) To create a 2D smart house environment using OpenGL
b) To simulate different weather conditions (rain, cloudy, normal)
c) To implement keyboard-based interaction for weather control
d) To enable mouse-based switching between day and night modes
e) To demonstrate real-time rendering and animation
f) To improve understanding of OpenGL primitives and transformations

1.4 Feasibility Study

The feasibility of this project is evaluated based on technical, operational, and economic aspects.

Technical Feasibility

The project uses OpenGL and C programming, which are lightweight and widely supported. No advanced hardware is required.

Operational Feasibility

The system is easy to operate. Users can control the simulation using simple keyboard and mouse inputs.

Economic Feasibility

The project is cost-effective as it uses free and open-source tools.

1.5 Gap Analysis

Many existing beginner projects lack interactivity and environmental realism.

Identified Gaps:

a) Static graphical scenes
b) No weather simulation
c) Limited user interaction
d) No dynamic lighting changes

Proposed Solutions:

a) Introduce interactive weather controls
b) Implement dynamic rain and cloud effects
c) Enable day/night switching
d) Add real-time scene updates

1.6 Project Outcome

The final outcome of this project is a fully functional smart house simulation system where:

a) Users can control weather conditions dynamically
b) Visual elements respond instantly to input
c) The system demonstrates smooth animation and rendering
d) The project serves as an educational tool for learning computer graphics

Chapter 2: Proposed Methodology

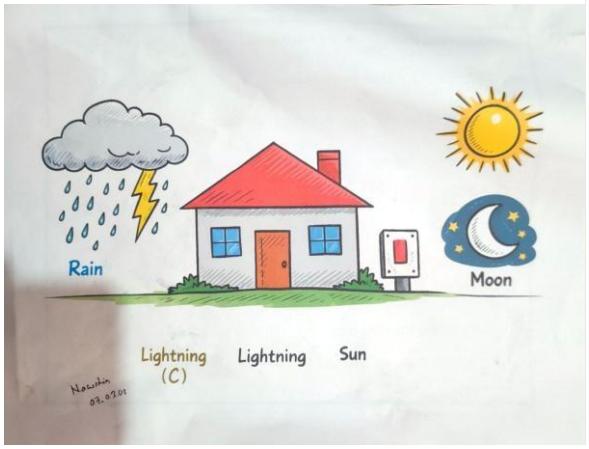
2.1 Requirement Analysis & Design Specification

Functional Requirements

a) Draw house, sky, sun, clouds, and environment
b) Simulate rainfall effect
c) Display cloudy weather
d) Restore normal weather conditions
e) Change window colors
f) Switch between day and night modes

Non-Functional Requirements

a) Smooth rendering without flickering
b) Easy-to-use controls
c) Efficient performance
d) Maintainable and modular code



Smart House Weather Simulation using OpenGL

Keyboard Control

R key:
Rain will start. The sun and moon will not be visible.

C key:
A cloudy sky will appear. The sun and moon will not be visible.

X key:
The sky will become normal (no rain or cloud). The sun will be visible again and light will appear.

D key:
The color of the house windows will turn white.

F key:
The color of the house windows will turn black.

Using Mouse Click:
By clicking the left mouse button, the scene will turn dark (night mode).
By clicking the right mouse button, the scene will return to normal (day mode).

2.1.1 Overview

The project is a 2D simulation where multiple graphical elements are combined to form a complete environment. The system continuously updates the display to reflect changes in weather and lighting conditions.

2.1.2 Proposed Methodology & System Design

The system is designed using a modular and layered architecture:

1. Rendering Layer

Responsible for drawing all objects:

a) House structure
b) Windows and doors
c) Sky and sun
d) Clouds and rain

2. Weather Control Layer

Manages environmental changes:

a) Rain effect using line primitives
b) Cloud rendering
c) Visibility of sun

3. Interaction Layer

Handles user input:

a) Keyboard inputs for weather control
b) Mouse inputs for day/night switching

4. Animation Layer

Updates scene continuously using display loops.

2.2 Overall Project Plan

The development followed these steps:

1. Designing the basic house structure
2. Implementing graphical primitives
3. Adding weather simulation features
4. Integrating user interaction
5. Testing and debugging

Chapter 3: Implementation and Results

3.1 Implementation

The project is implemented using:

a) **Programming Language:** C
b) **Graphics Library:** OpenGL (GLUT)

Key Components:

a) **House:** Drawn using polygons
b) **Rain:** Simulated using line segments
c) **Clouds:** Created using circles
d) **Sun:** Represented by a circle
e) **Windows:** Color change feature

Controls Implemented:

a) **R Key:** Start rain
b) **C Key:** Show clouds
c) **X Key:** Normal weather
d) **D Key:** Windows white
e) **F Key:** Windows black
f) **Mouse Left Click:** Night mode
g) **Mouse Right Click:** Day mode

3.2 Performance Analysis

The system was tested for:

a) Rendering smoothness
b) Input responsiveness
c) Animation stability

Results:

a) Smooth animation achieved
b) No flickering due to double buffering
c) Immediate response to user inputs

3.3 Results and Discussion

The project successfully demonstrates:

a) Real-time weather simulation
b) Interactive graphical control
c) Efficient use of OpenGL primitives

The visual output is clear, responsive, and educational.

Chapter 4: Engineering Standards and Mapping

4.1 Impact on Society, Environment and Sustainability

Impact on Life

Helps students understand graphics concepts through visualization.

Impact on Society

Can be used as an educational demonstration tool.

Ethical Aspects

a) No harmful content
b) No data collection
c) Purely educational use

Sustainability

a) Digital simulation reduces physical resource usage
b) Easily extendable for future projects

4.2 Project Management and Team Work

The project followed a structured development approach:

a) Planning
b) Design
c) Implementation
d) Testing

4.3 Complex Engineering Problem

The **Smart House Weather Simulation Using OpenGL** project involves solving a complex engineering problem that integrates real-time rendering, user interaction, and environmental simulation within a unified system.

The complexity arises from:

a) Managing multiple weather states (rain, cloudy, normal) dynamically
b) Synchronizing keyboard and mouse input with rendering
c) Maintaining smooth animation while updating scene conditions
d) Handling visibility of objects (sun, clouds, rain) based on user input

The system ensures that all components work together without disrupting performance or visual consistency.

4.3.1 Mapping of Program Outcome

Table 4-1: Justification of Program Outcomes

PO's	Justification
Engineering Knowledge (PO1)	Applied fundamental knowledge of computer graphics, including OpenGL primitives, coordinate systems, and rendering techniques to develop a complete smart house simulation system.
Problem Analysis (PO2)	Identified the need for dynamic weather simulation and analyzed how different environmental states can be represented and controlled interactively within a graphical system.
Design/Development of Solutions (PO3)	Designed a modular system that integrates rendering, animation, and user interaction. Developed features such as weather switching, day/night mode, and window color changes.

4.3.2 Complex Problem Solving

Table 4-2: Mapping with Complex Problem Solving

EP	Description (Applied in Project)
EP1 – Depth of Knowledge	Used core concepts of computer graphics and OpenGL to design the simulation system.

EP2 – Conflicting Requirements	Managed multiple weather conditions and ensured smooth transitions without affecting performance.
EP3 – Depth of Analysis	Analyzed how different inputs (keyboard/mouse) affect rendering and visual output.
EP4 – Familiarity of Issues	Worked with common graphics problems like flickering, object visibility, and animation control.
EP5 – Applicable Standards	Followed OpenGL programming standards and structured coding practices.
EP6 – Stakeholder Involvement	Designed the system to be user-friendly for learners and evaluators.
EP7 – Interdependence	Ensured interaction between modules such as weather control, rendering, and input handling.

4.3.3 Engineering Activities

Table 4-3: Mapping with Engineering Activities

EA	Description (Applied in Project)
EA1 – Range of Resources	Used OpenGL, GLUT, and C programming to implement the system.
EA2 – Level of Interaction	Implemented real-time user interaction using keyboard and mouse inputs.
EA3 – Innovation	Introduced dynamic weather simulation in a smart house environment.
EA	**Description (Applied in Project)**
EA4 – Impact on Society & Environment	Created an educational tool for understanding environmental simulation digitally.
EA5 – Familiarity	Built using commonly used tools and techniques in computer graphics.

Chapter 5: Conclusion

5.1 Summary

This project successfully demonstrates how a smart house environment can be simulated using OpenGL with interactive weather control and dynamic lighting.

5.2 Limitations

a) Limited to 2D graphics
b) No advanced lighting or shading
c) Basic weather effects only

5.3 Future Work

Future improvements may include:

a) Adding snowfall and storms
b) Implementing 3D graphics
c) Adding sound effects
d) Enhancing realism with textures

Chapter 6: References

a) OpenGL Documentation
b) Computer Graphics Textbooks
c) Online OpenGL Tutorials