**OpenGL Scene - Graphic Processing Project**

**A day at the Farm**

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**2. Subject Specification**

This documentation describes a 3D computer graphics project depicting serene and dynamic farm scene. The environment showcases a vibrant and detailed representation of rural life. The terrain is complex with various heights and a lake where ducks float peacefully. Animals, such as cows and pigs, complete the rural atmosphere, alongside a barn and a farmhouse, each with detailed textures specifically designed to reflect the rustic architecture. Cows in a farm

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The project focuses on delivering realistic graphics while implementing advanced OpenGL features, such as dynamic lighting, animations, and interactive weather effects.

**3. Scenario**

**3.1. Scene and Objects Description**

The farm scene includes:

* A **farmhouse** and **barn** with textured roofs and wooden walls.
* A **silo** used to store grain or food products
* **Animals**, such as cows grazing and pigs roaming around.
* A **lake with animated ducks.**
* **Tractor** parked near the barn, with potential animation for movement.
* **Fence** enclosing the fields and yard, adding depth to the scene.

The scene comes alive with features like:

* **Dynamic skyboxes**.
* **Interactive weather systems**, including fog and sunlight.

**3.2. Functionalities**

1. **Camera Control and Animation**
   * Free camera movement and mouse look.
   * Predefined paths for cinematic overviews.
2. **Dynamic Lighting**
   * Sunlight intensity changes based on time of day.

**A green tractor and pigs in a field

Description automatically generated**A green tractor in a field with sheep in the background

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1. **Fog Effect**

A farm with a tractor and pigs in a fenced in yard

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1. **Animal Animation**
   * Ducks swimming in the lake.
2. **Surface Visualization**
   * Options to toggle between solid, wireframe, and textured views.

A screenshot of a video game

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A group of cows and pigs

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**4. Implementation Details**

**4.1. Per Feature Design & Implementation**

1. **Camera and Animation**
   * The camera system uses vectors for position, direction, and up orientation. Smooth transitions are achieved through linear interpolation along predefined paths.
   * Cinematic animations highlight key scene features, such as the lake, barn, and fields.
2. **Lighting**

* Directional sunlight provides realistic illumination and interacts with shadow maps to create depth.

The **Phong lighting model** is applied for each point of light, combining:

* **Ambient** light for consistent base illumination.
* **Diffuse** light for angle-based intensity changes.
* **Specular** light for reflective highlights.
* Attenuation to ensure light fades realistically with distance.

1. **Animal Animation**

* Animals have predefined idle and movement cycles.
* Animations are synchronized with the environment, such as ducks reacting to water ripples.
* A script determines randomized patterns for each animal's behavior, avoiding repetition.

1. **Fog Effect**

* Fog introduces atmospheric depth and realism by blending fragment colors with the fog color based on distance.
* The effect is computed using an **exponential formula** controlled by density parameters.

**4.2. Graphics Model**

The project leverages OpenGL 4.1 Core features to achieve high-performance rendering, complemented by GLFW for cross-platform window management and real-time user input handling. GLEW is utilized for the loading of OpenGL extensions where applicable, and GLM serves as the mathematical backbone for vector and matrix transformations.

For content creation, **Blender** was used to design and assemble assets such as the terrain, the lake, and other components . Each asset underwent preprocessing, including applying accurate scaling, orientation adjustments, and UV unwrapping for optimal texture mapping before export.

**4.3 Data Structures**

* 1. Camera: contains the implementation of camera movements.
  2. Main: main project functionalities.
  3. Shader: loads and links the vertex and fragment shaders.

**A screenshot of a computer

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**5. Graphical User Interface Presentation & User Manual**

**Keyboard Controls**

* **W/A/S/D**: Move the camera.
* **V**: Switch between visualization modes (solid, wireframe, textured).
* **F**: Toggle fog.
* **U/I**: Move the camera up and down.
* **R**: Reset the Camera.
* **J/L:** Switch between day and night.
* **T**: Start cinematic camera animation.
* **ESC**: Exit the application.

**Mouse Controls**

* Rotate the camera view (yaw/pitch).

**6. Conclusions and Further Developments**

This project demonstrates:

* Realistic farm environments using OpenGL.
* Dynamic weather, animations, and lighting.
* Advanced GPU optimizations.

**Future Improvements**:

1. Implement collision detection to prevent camera clipping.
2. More complex animations.
3. Introduce seasonal changes and snow effects.
4. Sound design.
5. Point lighting objects.
6. Shadows for all the objects in the scene

**7. References**

1. OpenGL Programming Guide – Official documentation for modern OpenGL usage.
2. GLFW Documentation – For window and input handling.
3. YouTube tutorials -https://www.youtube.com/playlist?list=PLrgcDEgRZ\_kndoWmRkAK4Y7ToJdOf-OSM
4. Laboratory Works – UTCN, Graphic Processing Course 2024-2025 sem1