# Project Report

Fish Tank Demo

Principal of Computer Graphics

Creator

Mohamad Chamanmotlagh

# Contents

# Introduction

This project demonstrates the creation of a dynamic and interactive 3D scene using OpenGL and modern rendering techniques. The project consists of two main scenes:

- **Scene 1:** The external view of an aquarium placed on a table.
- **Scene 2:** The internal view of the aquarium, featuring animated objects such as fish, bubbles, and dynamic lighting.

The objective of the project is to showcase advanced 3D rendering capabilities, procedural content generation, animations, lighting effects, and post-processing.

# Data Structures

### Scene Graph

The scene graph is implemented as a hierarchical tree structure. Each node represents an object in the scene, and transformations are propagated hierarchically. The tree allows for logical spatial arrangement and hierarchical transformations.

- **Root Node**: Represents the scene itself (e.g., room in Scene 1, aquarium in Scene 2).
- **Child Nodes**: Objects like the table, lamp, aquarium, fish, and bubbles.

### Class Diagram

The project uses object-oriented design to organize its components.

- **Scene Class**: Manages all objects, lights, and the camera.
- **Object Class**: Base class for all scene objects, featuring properties like position, rotation, and scale.
- **Derived Classes**: Include Lamp, Table, Fish, Bubble, and BezierSurface.

# Interesting Algorithms

**Procedural Object Placement**

- Asteroids in Scene 2 are placed using a non-deterministic algorithm, ensuring random yet realistic placement. Positions are constrained by the ground boundaries defined by the Bézier surface.

**Bézier Surface for Ground**

- The ground is generated using a Bézier surface defined by 16 control points. Each vertex's position is calculated using the Bézier interpolation formula.

**Collision Detection**

- Bounding spheres are used for collision detection between objects, ensuring dynamic responses like bouncing and reflecting.

**Keyframe Animation**

- Fish and camera movements are interpolated using keyframes. Smooth transitions are achieved using non-linear interpolation techniques.

# Description of Scenes

**Scene 1: The External View**

- **Objects**: Table, lamp, aquarium, and room background.
- **Lighting**: Includes a directional light (representing sunlight) and a point light from the lamp.
- **Camera**: Starts from a fixed position and moves toward the aquarium using a Bézier curve path.

**Scene 2: The Internal View**

- **Objects**: Fish (animated), bubbles (particle system), ground (Bézier surface), chest (animated opening/closing).
- **Lighting**: Simulates underwater effects using a combination of ambient and point lights.
- **Special Effects**:
    - Bubbles are generated procedurally and ascend to the surface.

**Scene Graph Representation**

- **Scene 1 Graph**:
    - Room
        - Table
            - Lamp
            - Aquarium
- **Scene 2 Graph**:
    - Aquarium
        - Ground (Bézier Surface)
        - Fish (3 types)
        - Bubbles

# Description of Graphics Effects

**Lighting**

- **Types**: Directional, point, and spotlight.
- **Implementation**: Phong lighting model with multiple light sources.

**Procedural Animations**

- Fish use procedural animations to simulate swimming behavior.
- The chest animation combines procedural and keyframe animations.

**Post-Processing**

- **Filters**:
    - Grayscale filter for debugging.
    - Convolutional filters for sharpening and blurring.
    - Advanced bloom effect for realistic underwater lighting.

# Screenshots and Storyboard

**Storyboard**

The following images illustrate the sequence of events in the scenes:

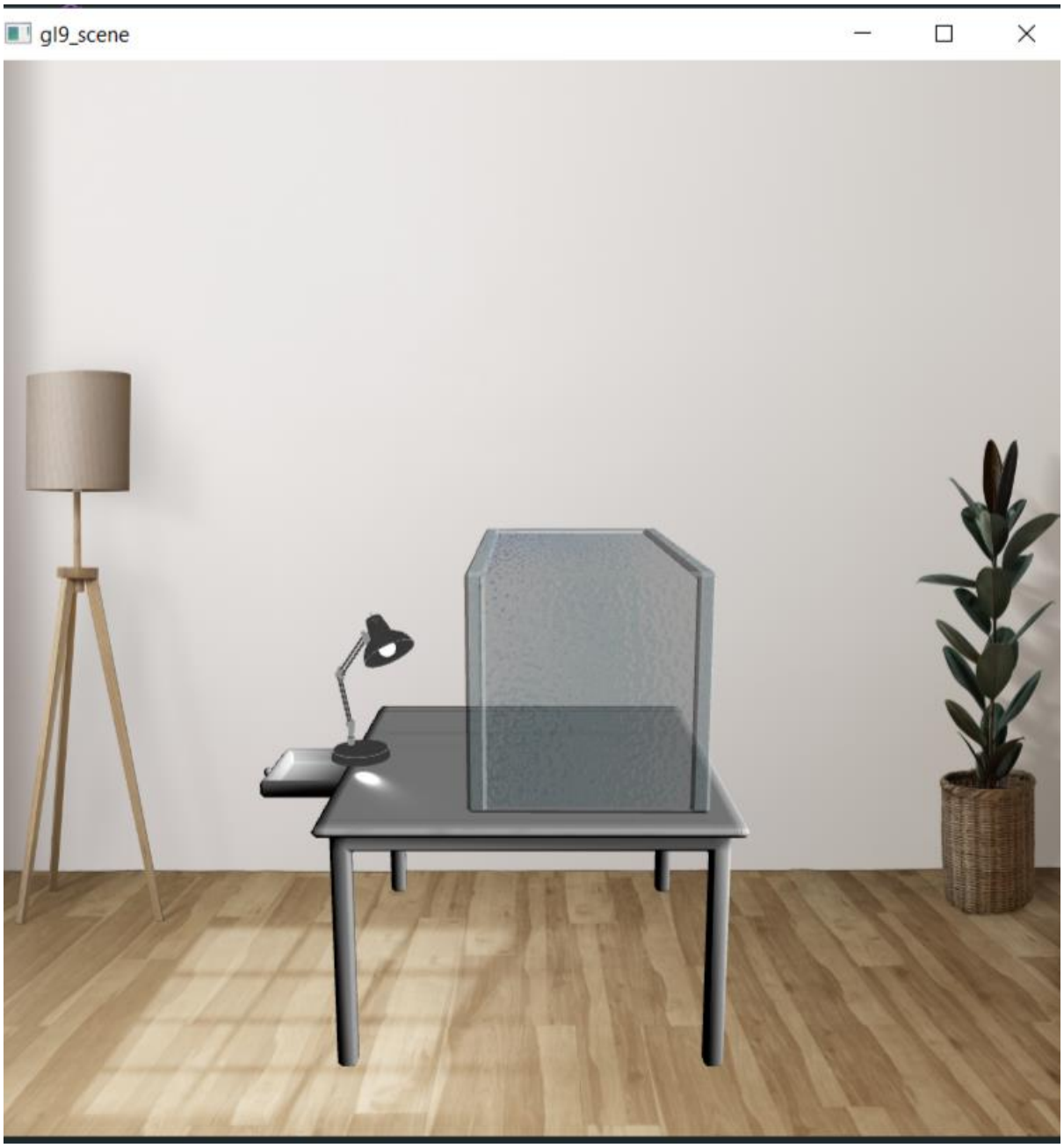
**Scene 1:**

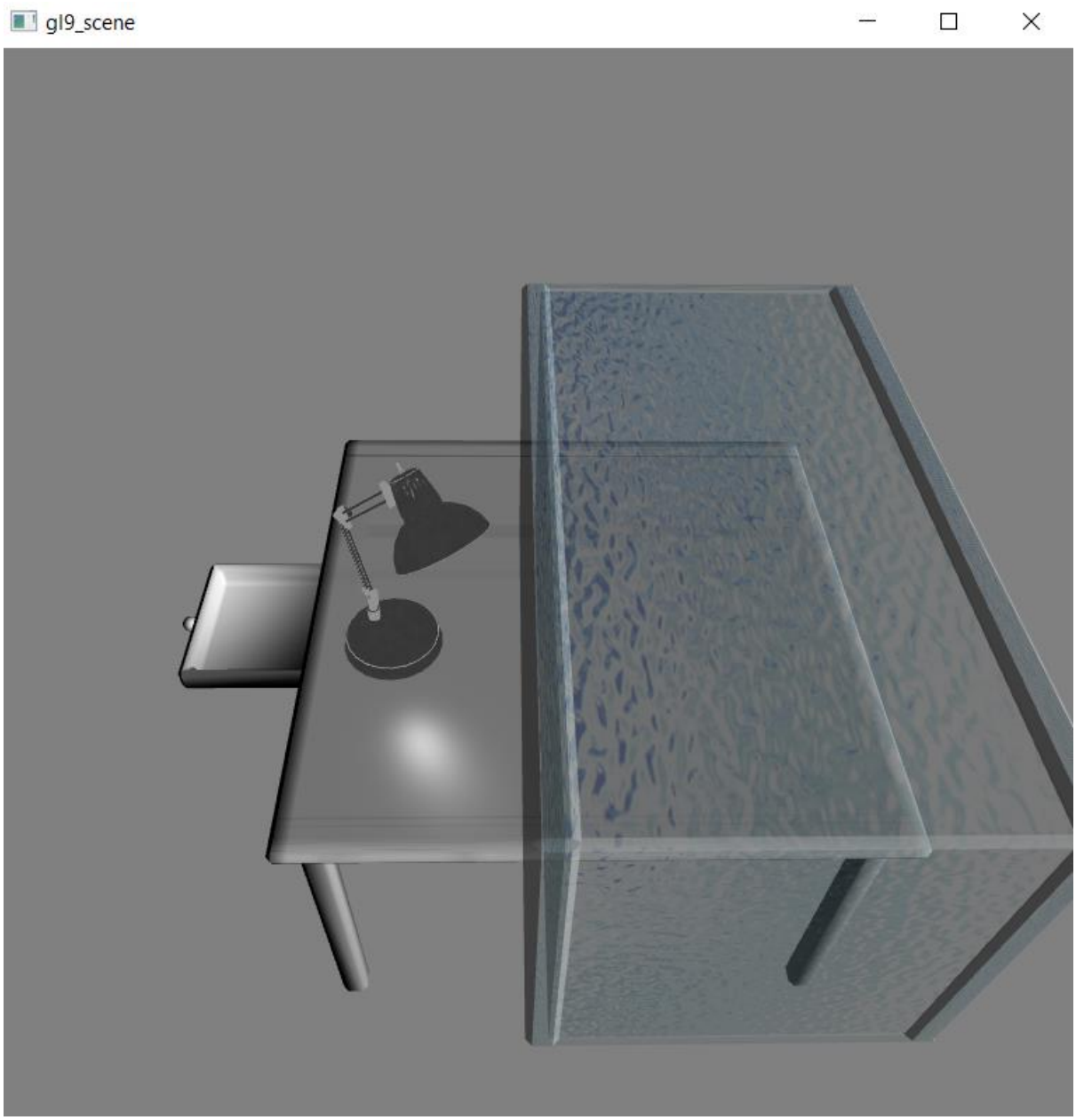
1. The camera starts at a fixed position showing the room, then goes around the table on a Bezier-curve with defined control points.
2. The camera moves closer to the aquarium, focusing on the table and lamp.
3. The view transitions into the aquarium (Scene 2).

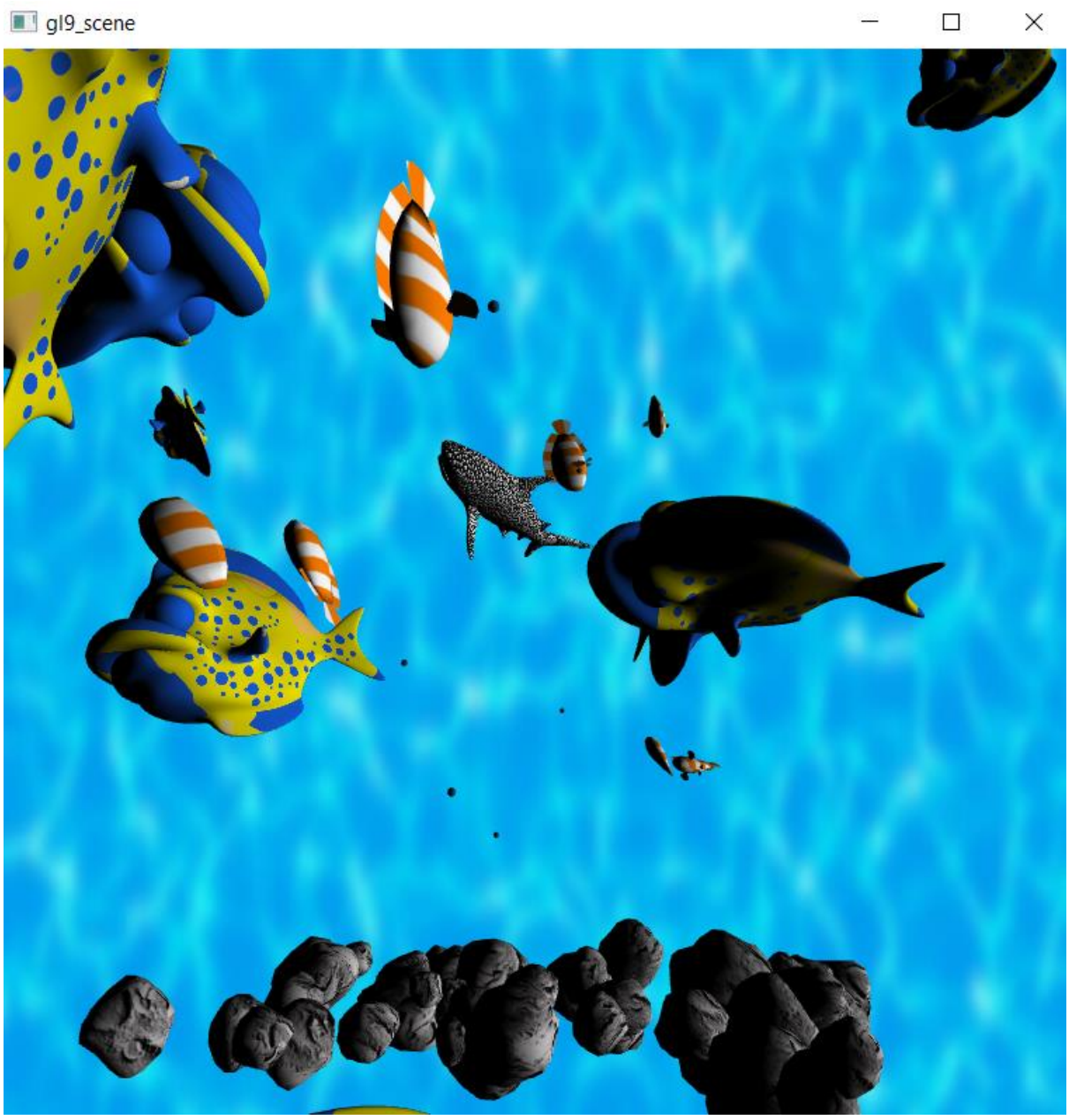
**Scene 2:**

1. The camera reveals the ground and the swimming fish.
2. Bubbles rise dynamically as fish swim past them.
3. Sharks sometimes attack the fish when they are close, and the fish move in the opposite direction.

# Screenshots




gl9_scene


gl9_scene