МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ імені ІГОРЯ СІКОРСЬКОГО»

ФАКУЛЬТЕТ ІНФОРМАТИКИ ТА ОБЧИСЛЮВАЛЬНОЇ ТЕХНІКИ

Кафедра інформатики та програмної інженерії

**Звіт**

З лабораторної роботи № 5 з дисципліни

«Програмування комп'ютерної графіки»

«**Використання текстур**»

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# ОСНОВНА ЧАСТИНА

**Мета роботи**: Отримати навички програмування текстур тривимірних об’єктів

засобами графіки OpenGL ES.

**Завдання**:

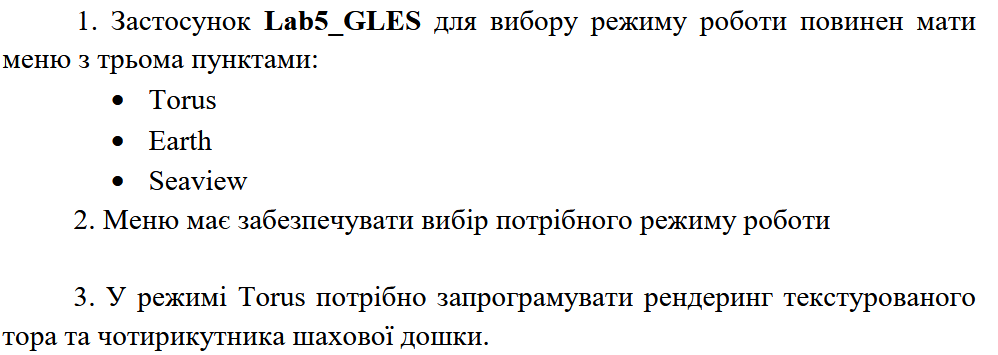


Рисунок 1.1 – Завдання лабораторної роботи

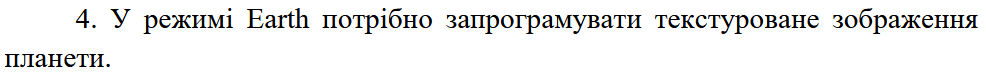


Рисунок 1.2 – Завдання лабораторного практикуму

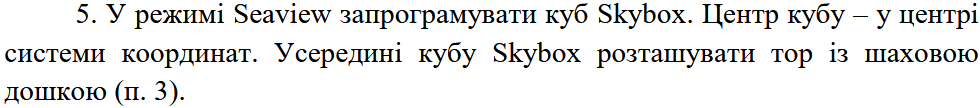


Рисунок 1.3 – Завдання лабораторного практикуму

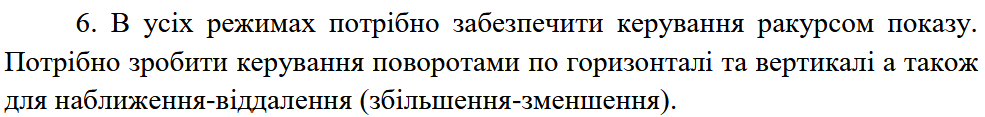


Рисунок 1.4 – Завдання лабораторного практикуму



Рисунок 1.5 – Отриманий рендер планети

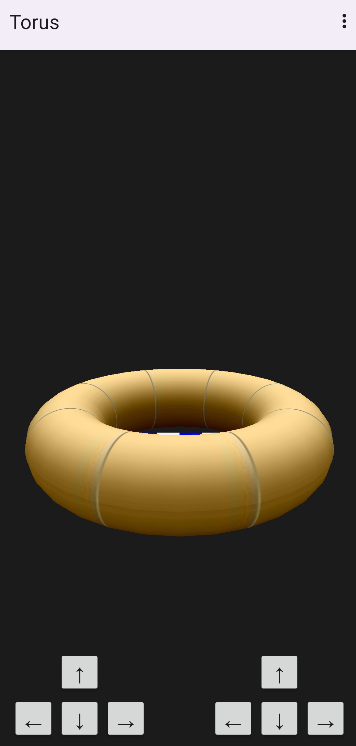


Рисунок 1.6 – Отриманий рендер торуса



Рисунок 1.7 – Отриманий рендер торуса зі скайбоксом

**Component.java**

package com.labwork.texturesexample.core.components.common;

import com.labwork.texturesexample.core.general.Entity;

public class Component {

private static int nextId;

private final int id;

private final Entity entity;

private boolean isActive;

public Component(Entity entity) {

this.entity = entity;

this.id = ++Component.nextId;

}

public int getId() {

return this.id;

}

public Entity getEntity() {

return this.entity;

}

public boolean getIsActive() {

return this.isActive;

}

public void setIsActive(boolean value) {

this.isActive = value;

}

public void onStart() {}

public void onUpdate(float deltaTime) {}

public void onDestroy() {}

}

**CameraComponent.java**

package com.labwork.texturesexample.core.components.concrete;

import android.opengl.Matrix;

import com.labwork.texturesexample.core.general.Color;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.components.common.Component;

public class CameraComponent extends Component {

private static final int MATRIX\_DIMENSIONS\_COUNT = 16;

protected final float[] matrixView;

protected final float[] matrixProjection;

protected Color backgroundColor;

protected float farClippingPlane;

protected float nearClippingPlane;

public CameraComponent(Entity entity, Color color, float nearClippingPlane, float farClippingPlane) {

super(entity);

this.backgroundColor = color;

this.farClippingPlane = farClippingPlane;

this.nearClippingPlane = nearClippingPlane;

this.matrixView = new float[CameraComponent.MATRIX\_DIMENSIONS\_COUNT];

this.matrixProjection = new float[CameraComponent.MATRIX\_DIMENSIONS\_COUNT];

Matrix.setIdentityM(this.matrixView, 0);

Matrix.setIdentityM(this.matrixProjection, 0);

}

public float[] getMatrixView() {

return this.matrixView;

}

public float[] getMatrixProjection() {

return this.matrixProjection;

}

public Color getBackgroundColor() {

return this.backgroundColor;

}

public void setBackgroundColor(Color value) {

this.backgroundColor = value;

}

public float getFarClippingPlane() {

return this.farClippingPlane;

}

public void setFarClippingPlane(float value) {

this.farClippingPlane = value;

}

public float getNearClippingPlane() {

return this.nearClippingPlane;

}

public void setNearClippingPlane(float value) {

this.nearClippingPlane = value;

}

}

**CameraPerspectiveComponent.java**

package com.labwork.texturesexample.core.components.concrete;

import android.opengl.GLES32;

import android.opengl.Matrix;

import android.opengl.GLSurfaceView;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Color;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Vector3;

public final class CameraPerspectiveComponent extends CameraComponent {

private final Vector3 target;

private final GLSurfaceView viewport;

private Vector3 up;

private Vector3 position;

private float aspectRatio;

private float fieldOfView;

private TransformComponent transform;

public CameraPerspectiveComponent(Entity entity, Color color, float nearClippingPlane, float farClippingPlane, float aspectRatio, float fieldOfView) {

super(entity, color, nearClippingPlane, farClippingPlane);

this.viewport = Framework.getInstance().getSurfaceView();

this.fieldOfView = fieldOfView;

this.aspectRatio = aspectRatio;

this.up = new Vector3(0.0f, 1.0f, 0.0f);

this.target = new Vector3(0.0f, 0.0f, 1.0f);

this.position = new Vector3(0.0f, 0.0f, 0.0f);

}

public float getAspectRatio() {

return this.aspectRatio;

}

public void setAspectRatio(float value) {

this.aspectRatio = value;

}

public float getFieldOfView() {

return this.fieldOfView;

}

public void setFieldOfView(float value) {

this.fieldOfView = value;

}

@Override

public void onStart() {

this.transform = super.getEntity().getComponent(TransformComponent.class);

this.up = this.transform.getUp();

this.position = this.transform.getPosition();

}

@Override

public void onUpdate(float deltaTime) {

this.setAspectRatio((float)this.viewport.getWidth() / this.viewport.getHeight());

GLES32.glClearColor(super.backgroundColor.getRNormalized(), super.backgroundColor.getGNormalized(), super.backgroundColor.getBNormalized(), super.backgroundColor.getANormalized());

Vector3.add(this.transform.getPosition(), this.transform.getForward(), this.target);

Matrix.perspectiveM(super.matrixProjection, 0, this.fieldOfView, this.aspectRatio, super.nearClippingPlane, super.farClippingPlane);

Matrix.setLookAtM(super.matrixView, 0, this.position.getX(), this.position.getY(), this.position.getZ(), this.target.getX(), this.target.getY(), this.target.getZ(), this.up.getX(), this.up.getY(), this.up.getZ());

}

}

**OpaqueRenderingComponent.java**

package com.labwork.texturesexample.core.components.concrete;

import android.opengl.GLES32;

import com.labwork.texturesexample.core.general.Mesh;

import com.labwork.texturesexample.core.general.Color;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Shader;

import com.labwork.texturesexample.core.general.Material;

import com.labwork.texturesexample.core.components.common.Component;

public final class OpaqueRenderingComponent extends Component {

private static final int TEXTURE\_UNIT\_INDEX\_OPAQUE = 0;

private Mesh mesh;

private Material material;

private TransformComponent transform;

public OpaqueRenderingComponent(Entity entity, Mesh mesh, Material material) {

super(entity);

this.mesh = mesh;

this.material = material;

}

public Mesh getMesh() {

return this.mesh;

}

public void setMesh(Mesh value) {

this.mesh = value;

}

public Material getMaterial() {

return this.material;

}

public void setMaterial(Material value) {

this.material = value;

}

@Override

public void onStart() {

this.transform = super.getEntity().getComponent(TransformComponent.class);

}

public void render() {

Shader shader = this.material.getShader();

GLES32.glUniformMatrix4fv(shader.getVariableHandler("uMatrixModel"), 1, false, this.transform.getMatrixModel(), 0);

Color color = this.material.getColor();

GLES32.glUniform4f(shader.getVariableHandler("uMaterialColorRGBA"), color.getRNormalized(), color.getGNormalized(), color.getBNormalized(), color.getANormalized());

GLES32.glBindTexture(GLES32.GL\_TEXTURE\_2D, this.material.getTextureAlbedo().getId());

GLES32.glUniform1i(shader.getVariableHandler("uTextureAlbedo"), OpaqueRenderingComponent.TEXTURE\_UNIT\_INDEX\_OPAQUE);

this.mesh.draw();

}

}

**SkyboxRenderingComponent.java**

package com.labwork.texturesexample.core.components.concrete;

import android.opengl.GLES32;

import com.labwork.texturesexample.core.general.Mesh;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Color;

import com.labwork.texturesexample.core.general.Shader;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Material;

import com.labwork.texturesexample.core.general.Texture3D;

import com.labwork.texturesexample.core.components.common.Component;

public final class SkyboxRenderingComponent extends Component {

private static final int TEXTURE\_UNIT\_INDEX\_SKYBOX = 0;

private final Mesh mesh;

private final Texture3D cubeTexture;

private Material material;

private TransformComponent transform;

public SkyboxRenderingComponent(Entity entity, Mesh mesh, Material material, Texture3D cubeTexture) {

super(entity);

this.mesh = mesh;

this.material = material;

this.cubeTexture = cubeTexture;

}

public Mesh getMesh() {

return this.mesh;

}

public Material getMaterial() {

return this.material;

}

public void setMaterial(Material value) {

this.material = value;

}

@Override

public final void onStart() {

this.transform = super.getEntity().getComponent(TransformComponent.class);

}

public void render() {

Shader shader = this.material.getShader();

GLES32.glUniformMatrix4fv(shader.getVariableHandler("uMatrixModel"), 1, false, this.transform.getMatrixModel(), 0);

Color color = this.material.getColor();

GLES32.glUniform4f(shader.getVariableHandler("uMaterialColorRGBA"), color.getRNormalized(), color.getGNormalized(), color.getBNormalized(), color.getANormalized());

GLES32.glBindTexture(GLES32.GL\_TEXTURE\_CUBE\_MAP, this.cubeTexture.getId());

GLES32.glUniform1i(shader.getVariableHandler("uCubemapTextureAlbedo"), SkyboxRenderingComponent.TEXTURE\_UNIT\_INDEX\_SKYBOX);

this.mesh.draw();

}

}

**TransformComponent.java**

package com.labwork.texturesexample.core.components.concrete;

import android.opengl.Matrix;

import com.labwork.texturesexample.core.general.Axis;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Vector3;

import com.labwork.texturesexample.core.components.common.Component;

public final class TransformComponent extends Component {

private static final int MATRIX\_OUTPUT\_DIMENSIONS\_COUNT = 16;

private static final int MATRIX\_INTERMEDIATE\_DIMENSIONS\_COUNT = 4;

private static final float[] MATRIX\_VECTOR\_UP = { 0.0f, 1.0f, 0.0f, 0.0f };

private static final float[] MATRIX\_VECTOR\_RIGHT = { 1.0f, 0.0f, 0.0f, 0.0f };

private static final float[] MATRIX\_VECTOR\_FORWARD = { 0.0f, 0.0f, 1.0f, 0.0f };

private final Vector3 scale;

private final Vector3 rotation;

private final Vector3 position;

private final Vector3 vectorUp;

private final Vector3 vectorRight;

private final Vector3 vectorForward;

private final float[] matrixModel;

private final float[] matrixRotation;

private final float[] matrixRotationOutput;

public TransformComponent(Entity entity) {

super(entity);

this.matrixModel = new float[TransformComponent.MATRIX\_OUTPUT\_DIMENSIONS\_COUNT];

this.matrixRotation = new float[TransformComponent.MATRIX\_OUTPUT\_DIMENSIONS\_COUNT];

this.matrixRotationOutput = new float[TransformComponent.MATRIX\_INTERMEDIATE\_DIMENSIONS\_COUNT];

this.scale = new Vector3(1.0f, 1.0f, 1.0f);

this.rotation = new Vector3(0.0f, 0.0f, 0.0f);

this.position = new Vector3(0.0f, 0.0f, 0.0f);

this.vectorUp = new Vector3(0.0f, 0.0f, 0.0f);

this.vectorRight = new Vector3(0.0f, 0.0f, 0.0f);

this.vectorForward = new Vector3(0.0f, 0.0f, 0.0f);

}

public Vector3 getScale() {

return this.scale;

}

public void setScale(Vector3 value) {

this.scale.setX(value.getX());

this.scale.setY(value.getY());

this.scale.setZ(value.getZ());

}

public Vector3 getRotation() {

return this.rotation;

}

public void setRotation(Vector3 value) {

this.rotation.setX(value.getX());

this.rotation.setY(value.getY());

this.rotation.setZ(value.getZ());

}

public Vector3 getPosition() {

return this.position;

}

public void setPosition(Vector3 value) {

this.position.setX(value.getX());

this.position.setY(value.getY());

this.position.setZ(value.getZ());

}

public float[] getMatrixModel() {

Matrix.setIdentityM(this.matrixModel, 0);

Matrix.scaleM(this.matrixModel, 0, this.scale.getX(), this.scale.getY(), this.scale.getZ());

Matrix.rotateM(this.matrixModel, 0, this.rotation.getZ(), 0.0f, 0.0f, 1.0f);

Matrix.rotateM(this.matrixModel, 0, this.rotation.getY(), 0.0f, 1.0f, 0.0f);

Matrix.rotateM(this.matrixModel, 0, this.rotation.getX(), 1.0f, 0.0f, 0.0f);

Matrix.translateM(this.matrixModel, 0, this.position.getX(), this.position.getY(), this.position.getZ());

return this.matrixModel;

}

public Vector3 getUp() {

Matrix.multiplyMV(this.matrixRotationOutput, 0, this.getRotationMatrix(), 0, TransformComponent.MATRIX\_VECTOR\_UP, 0);

this.vectorUp.setX(this.matrixRotationOutput[Axis.X.ordinal()]);

this.vectorUp.setY(this.matrixRotationOutput[Axis.Y.ordinal()]);

this.vectorUp.setZ(this.matrixRotationOutput[Axis.Z.ordinal()]);

Vector3.normalize(this.vectorUp, this.vectorUp);

return this.vectorUp;

}

public Vector3 getRight() {

Matrix.multiplyMV(this.matrixRotationOutput, 0, this.getRotationMatrix(), 0, TransformComponent.MATRIX\_VECTOR\_RIGHT, 0);

this.vectorRight.setX(this.matrixRotationOutput[Axis.X.ordinal()]);

this.vectorRight.setY(this.matrixRotationOutput[Axis.Y.ordinal()]);

this.vectorRight.setZ(this.matrixRotationOutput[Axis.Z.ordinal()]);

Vector3.normalize(this.vectorRight, this.vectorRight);

return this.vectorRight;

}

public Vector3 getForward() {

Matrix.multiplyMV(this.matrixRotationOutput, 0, this.getRotationMatrix(), 0, TransformComponent.MATRIX\_VECTOR\_FORWARD, 0);

this.vectorForward.setX(this.matrixRotationOutput[Axis.X.ordinal()]);

this.vectorForward.setY(this.matrixRotationOutput[Axis.Y.ordinal()]);

this.vectorForward.setZ(this.matrixRotationOutput[Axis.Z.ordinal()]);

Vector3.normalize(this.vectorForward, this.vectorForward);

return this.vectorForward;

}

private float[] getRotationMatrix() {

Matrix.setIdentityM(this.matrixRotation, 0);

Matrix.rotateM(this.matrixRotation, 0, this.rotation.getZ(), 0.0f, 0.0f, 1.0f);

Matrix.rotateM(this.matrixRotation, 0, this.rotation.getY(), 0.0f, 1.0f, 0.0f);

Matrix.rotateM(this.matrixRotation, 0, this.rotation.getX(), 1.0f, 0.0f, 0.0f);

return this.matrixRotation;

}

}

**Axis.java**

package com.labwork.texturesexample.core.general;

public enum Axis {

X,

Y,

Z,

}

**Color.java**

package com.labwork.texturesexample.core.general;

public final class Color {

private static final float MAX\_CHANNEL\_VALUE = 255.0f;

private int r, g, b, a;

private float rNormalized, gNormalized, bNormalized, aNormalized;

public Color(int r, int g, int b, int a) {

this.r = r;

this.g = g;

this.b = b;

this.a = a;

this.rNormalized = r / Color.MAX\_CHANNEL\_VALUE;

this.gNormalized = g / Color.MAX\_CHANNEL\_VALUE;

this.bNormalized = b / Color.MAX\_CHANNEL\_VALUE;

this.aNormalized = a / Color.MAX\_CHANNEL\_VALUE;

}

public int getR() {

return this.r;

}

public void setR(int value) {

this.r = value;

this.rNormalized = value / Color.MAX\_CHANNEL\_VALUE;

}

public float getRNormalized() {

return this.rNormalized;

}

public int getG() {

return this.g;

}

public void setG(int value) {

this.g = value;

this.gNormalized = value / Color.MAX\_CHANNEL\_VALUE;

}

public float getGNormalized() {

return this.gNormalized;

}

public int getB() {

return this.b;

}

public void setB(int value) {

this.b = value;

this.bNormalized = value / Color.MAX\_CHANNEL\_VALUE;

}

public float getBNormalized() {

return this.bNormalized;

}

public int getA() {

return this.a;

}

public void setA(int value) {

this.a = value;

this.aNormalized = value / Color.MAX\_CHANNEL\_VALUE;

}

public float getANormalized() {

return this.aNormalized;

}

}

**Entity.java**

package com.labwork.texturesexample.core.general;

import java.util.Map;

import java.util.HashMap;

import java.util.Collection;

import com.labwork.texturesexample.core.components.common.Component;

public class Entity {

private static int nextId;

private final int id;

private final Map<Class<?>, Component> components;

private boolean isActive;

public Entity() {

this.isActive = true;

this.id = ++Entity.nextId;

this.components = new HashMap<>();

}

public int getId() {

return this.id;

}

public boolean getIsActive() {

return this.isActive;

}

public void setIsActive(boolean value) {

this.isActive = value;

}

public Collection<Component> getComponents() {

return this.components.values();

}

public void addComponent(Component component) {

if (this.components.containsKey(component.getClass()))

throw new IllegalArgumentException("Component of type " + component.getClass().getName() + " already exists.");

this.components.put(component.getClass(), component);

}

public boolean hasComponent(Class<?> component) {

return this.components.containsKey(component);

}

@SuppressWarnings("unchecked")

public <T extends Component> T getComponent(Class<T> component) {

return (T) this.components.getOrDefault(component, null);

}

public void onStart() {

for (Component component : this.components.values())

component.onStart();

}

public void onUpdate(float deltaTime) {

for (Component component : this.components.values())

component.onUpdate(deltaTime);

}

public void onDestroy() {

for (Component component : this.components.values())

component.onDestroy();

}

}

**Material.java**

package com.labwork.texturesexample.core.general;

public final class Material {

private Color color;

private Shader shader;

private float propertyAmbient;

private float propertyDiffuse;

private float propertySpecular;

private Texture2D textureAlbedo;

public Material(Shader shader, Color color, Texture2D textureAlbedo, float propertyAmbient, float propertyDiffuse, float propertySpecular) {

this.color = color;

this.shader = shader;

this.textureAlbedo = textureAlbedo;

this.propertyAmbient = propertyAmbient;

this.propertyDiffuse = propertyDiffuse;

this.propertySpecular = propertySpecular;

}

public Color getColor() {

return this.color;

}

public void setColor(Color value) {

this.color= value;

}

public Shader getShader() {

return this.shader;

}

public void setShader(Shader value) {

this.shader = value;

}

public Texture2D getTextureAlbedo() {

return this.textureAlbedo;

}

public void setTextureAlbedo(Texture2D value) {

this.textureAlbedo = value;

}

public float getPropertyAmbient() {

return this.propertyAmbient;

}

public void setPropertyAmbient(float value) {

this.propertyAmbient = value;

}

public float getPropertyDiffuse() {

return this.propertyDiffuse;

}

public void setPropertyDiffuse(float value) {

this.propertyDiffuse = value;

}

public float getPropertySpecular() {

return this.propertySpecular;

}

public void setPropertySpecular(float value) {

this.propertySpecular = value;

}

}

**Mesh.java**

package com.labwork.texturesexample.core.general;

import java.nio.ByteOrder;

import java.nio.ByteBuffer;

import java.nio.FloatBuffer;

import java.nio.IntBuffer;

import android.opengl.GLES32;

public final class Mesh {

private static final int HANDLERS\_COUNT = 3;

private static final int HANDLER\_INDEX\_VAO = 0;

private static final int HANDLER\_INDEX\_VBO = 1;

private static final int HANDLER\_INDEX\_EBO = 2;

public static final int PAYLOAD\_POSITION\_SIZE = 3;

public static final int PAYLOAD\_POSITION\_INDEX = 0;

public static final int PAYLOAD\_POSITION\_OFFSET = 0;

public static final int PAYLOAD\_TEXTURE\_SIZE = 2;

public static final int PAYLOAD\_TEXTURE\_INDEX = 1;

public static final int PAYLOAD\_TEXTURE\_OFFSET = (Mesh.PAYLOAD\_POSITION\_SIZE) \* Float.BYTES;

public static final int PAYLOAD\_NORMAL\_SIZE = 3;

public static final int PAYLOAD\_NORMAL\_INDEX = 2;

public static final int PAYLOAD\_NORMAL\_OFFSET = (Mesh.PAYLOAD\_POSITION\_SIZE + Mesh.PAYLOAD\_TEXTURE\_SIZE) \* Float.BYTES;

public static final int PAYLOAD\_COLOR\_SIZE = 3;

public static final int PAYLOAD\_COLOR\_INDEX = 3;

public static final int PAYLOAD\_COLOR\_OFFSET = (Mesh.PAYLOAD\_POSITION\_SIZE + Mesh.PAYLOAD\_TEXTURE\_SIZE + Mesh.PAYLOAD\_NORMAL\_SIZE) \* Float.BYTES;

public static final int PAYLOAD\_STRIDE = (Mesh.PAYLOAD\_POSITION\_SIZE + Mesh.PAYLOAD\_TEXTURE\_SIZE + Mesh.PAYLOAD\_NORMAL\_SIZE + Mesh.PAYLOAD\_COLOR\_SIZE) \* Float.BYTES;

private final int[] handlers;

private final int drawingMode;

private final int indicesCount;

public Mesh(float[] vertices, int[] indices, int drawingMode) {

this.drawingMode = drawingMode;

this.indicesCount = indices.length;

this.handlers = new int[Mesh.HANDLERS\_COUNT];

FloatBuffer vertexBuffer = ByteBuffer.allocateDirect(vertices.length \* Float.BYTES).order(ByteOrder.nativeOrder()).asFloatBuffer();

vertexBuffer.put(vertices).position(0);

IntBuffer indexBuffer = ByteBuffer.allocateDirect(indices.length \* Integer.BYTES).order(ByteOrder.nativeOrder()).asIntBuffer();

indexBuffer.put(indices).position(0);

GLES32.glGenVertexArrays(1, this.handlers, Mesh.HANDLER\_INDEX\_VAO);

GLES32.glGenBuffers(1, this.handlers, Mesh.HANDLER\_INDEX\_VBO);

GLES32.glGenBuffers(1, this.handlers, Mesh.HANDLER\_INDEX\_EBO);

GLES32.glBindVertexArray(this.handlers[Mesh.HANDLER\_INDEX\_VAO]);

GLES32.glBindBuffer(GLES32.GL\_ARRAY\_BUFFER, this.handlers[Mesh.HANDLER\_INDEX\_VBO]);

GLES32.glBufferData(GLES32.GL\_ARRAY\_BUFFER, vertices.length \* Float.BYTES, vertexBuffer, GLES32.GL\_STATIC\_DRAW);

GLES32.glBindBuffer(GLES32.GL\_ELEMENT\_ARRAY\_BUFFER, this.handlers[Mesh.HANDLER\_INDEX\_EBO]);

GLES32.glBufferData(GLES32.GL\_ELEMENT\_ARRAY\_BUFFER, indices.length \* Integer.BYTES, indexBuffer, GLES32.GL\_STATIC\_DRAW);

GLES32.glVertexAttribPointer(Mesh.PAYLOAD\_POSITION\_INDEX, Mesh.PAYLOAD\_POSITION\_SIZE, GLES32.GL\_FLOAT, false, Mesh.PAYLOAD\_STRIDE, Mesh.PAYLOAD\_POSITION\_OFFSET);

GLES32.glEnableVertexAttribArray(Mesh.PAYLOAD\_POSITION\_INDEX);

GLES32.glVertexAttribPointer(Mesh.PAYLOAD\_TEXTURE\_INDEX, Mesh.PAYLOAD\_TEXTURE\_SIZE, GLES32.GL\_FLOAT, false, Mesh.PAYLOAD\_STRIDE, Mesh.PAYLOAD\_TEXTURE\_OFFSET);

GLES32.glEnableVertexAttribArray(Mesh.PAYLOAD\_TEXTURE\_INDEX);

GLES32.glVertexAttribPointer(Mesh.PAYLOAD\_NORMAL\_INDEX, Mesh.PAYLOAD\_NORMAL\_SIZE, GLES32.GL\_FLOAT, false, Mesh.PAYLOAD\_STRIDE, Mesh.PAYLOAD\_NORMAL\_OFFSET);

GLES32.glEnableVertexAttribArray(Mesh.PAYLOAD\_NORMAL\_INDEX);

GLES32.glVertexAttribPointer(Mesh.PAYLOAD\_COLOR\_INDEX, Mesh.PAYLOAD\_COLOR\_SIZE, GLES32.GL\_FLOAT, false, Mesh.PAYLOAD\_STRIDE, Mesh.PAYLOAD\_COLOR\_OFFSET);

GLES32.glEnableVertexAttribArray(Mesh.PAYLOAD\_COLOR\_INDEX);

GLES32.glBindVertexArray(0);

GLES32.glBindBuffer(GLES32.GL\_ARRAY\_BUFFER, 0);

GLES32.glBindBuffer(GLES32.GL\_ELEMENT\_ARRAY\_BUFFER, 0);

}

public int getId() {

return this.handlers[Mesh.HANDLER\_INDEX\_VAO];

}

public void draw() {

GLES32.glBindVertexArray(this.handlers[Mesh.HANDLER\_INDEX\_VAO]);

GLES32.glDrawElements(this.drawingMode, this.indicesCount, GLES32.GL\_UNSIGNED\_INT, 0);

GLES32.glBindVertexArray(0);

}

public void delete() {

GLES32.glDeleteBuffers(this.handlers.length, this.handlers, 0);

}

}

**Scene.java**

package com.labwork.texturesexample.core.general;

import java.util.List;

import java.util.ArrayList;

import java.util.Collection;

import com.labwork.texturesexample.core.components.common.Component;

import com.labwork.texturesexample.core.components.concrete.CameraComponent;

import com.labwork.texturesexample.core.components.concrete.SkyboxRenderingComponent;

public final class Scene {

private final List<Entity> entities;

private CameraComponent camera;

private SkyboxRenderingComponent skybox;

public Scene() {

this.entities = new ArrayList<>();

}

public List<Entity> getEntities() {

return this.entities;

}

public CameraComponent getCamera() {

return this.camera;

}

public SkyboxRenderingComponent getSkybox() {

return this.skybox;

}

public void addEntity(Entity entity) {

this.entities.add(entity);

Collection<Component> components = entity.getComponents();

for (Component component : components) {

if (component instanceof CameraComponent) {

this.camera = (CameraComponent) component;

}

if (component instanceof SkyboxRenderingComponent) {

this.skybox = (SkyboxRenderingComponent) component;

}

}

}

public void onUnloaded() {

for (Entity entity: this.entities)

entity.onDestroy();

}

}

**Shader.java**

package com.labwork.texturesexample.core.general;

import android.opengl.GLES32;

public final class Shader {

private final int vertId;

private final int fragId;

private final int programId;

private final Class<?> renderFeature;

public Shader(Class<?> renderFeature, String sourceVert, String sourceFrag) {

this.renderFeature = renderFeature;

this.programId = GLES32.glCreateProgram();

this.vertId = GLES32.glCreateShader(GLES32.GL\_VERTEX\_SHADER);

GLES32.glShaderSource(this.vertId, sourceVert);

this.fragId = GLES32.glCreateShader(GLES32.GL\_FRAGMENT\_SHADER);

GLES32.glShaderSource(this.fragId, sourceFrag);

GLES32.glCompileShader(this.vertId);

GLES32.glCompileShader(this.fragId);

GLES32.glAttachShader(this.programId, this.vertId);

GLES32.glAttachShader(this.programId, this.fragId);

GLES32.glBindAttribLocation(this.programId, Mesh.PAYLOAD\_COLOR\_INDEX, "aVertexColorRGB");

GLES32.glBindAttribLocation(this.programId, Mesh.PAYLOAD\_NORMAL\_INDEX, "aVertexNormalLocal");

GLES32.glBindAttribLocation(this.programId, Mesh.PAYLOAD\_POSITION\_INDEX, "aVertexPositionLocal");

GLES32.glBindAttribLocation(this.programId, Mesh.PAYLOAD\_TEXTURE\_INDEX, "aVertexTextureCoordinate");

GLES32.glLinkProgram(this.programId);

}

public int getId() {

return this.programId;

}

public Class<?> getRenderFeature() {

return this.renderFeature;

}

public int getVariableHandler(String identifier) {

return GLES32.glGetUniformLocation(this.programId, identifier);

}

public void delete() {

GLES32.glDetachShader(this.programId, this.vertId);

GLES32.glDetachShader(this.programId, this.fragId);

GLES32.glDeleteShader(this.vertId);

GLES32.glDeleteShader(this.fragId);

GLES32.glDeleteProgram(this.programId);

}

}

Texture2D.java

package com.labwork.texturesexample.core.general;

import android.opengl.GLES32;

import android.opengl.GLUtils;

import android.content.Context;

import android.graphics.Bitmap;

import android.graphics.BitmapFactory;

public final class Texture2D {

private static final int HANDLERS\_COUNT = 1;

private static final int HANDLER\_INDEX\_ID = 0;

private final int[] handlers;

public Texture2D(Context context, int resourceId, int wrap, int filter) {

this.handlers = new int[Texture2D.HANDLERS\_COUNT];

GLES32.glGenTextures(1, this.handlers, 0);

final BitmapFactory.Options options = new BitmapFactory.Options();

options.inScaled = false;

final Bitmap bitmap = BitmapFactory.decodeResource(context.getResources(), resourceId, options);

GLES32.glBindTexture(GLES32.GL\_TEXTURE\_2D, this.handlers[Texture2D.HANDLER\_INDEX\_ID]);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_2D, GLES32.GL\_TEXTURE\_WRAP\_S, wrap);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_2D, GLES32.GL\_TEXTURE\_WRAP\_T, wrap);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_2D, GLES32.GL\_TEXTURE\_MIN\_FILTER, filter);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_2D, GLES32.GL\_TEXTURE\_MAG\_FILTER, filter);

GLUtils.texImage2D(GLES32.GL\_TEXTURE\_2D, 0, bitmap, 0);

bitmap.recycle();

GLES32.glBindTexture(GLES32.GL\_TEXTURE\_2D, 0);

}

public int getId() {

return this.handlers[Texture2D.HANDLER\_INDEX\_ID];

}

}

**Texture3D.java**

package com.labwork.texturesexample.core.general;

import android.opengl.GLES32;

import android.opengl.GLUtils;

import android.content.Context;

import android.graphics.Bitmap;

import android.graphics.BitmapFactory;

public final class Texture3D {

private static final int HANDLERS\_COUNT = 1;

private static final int HANDLER\_INDEX\_ID = 0;

private final int[] handlers;

public Texture3D(Context context, int[] resourceIds, int wrap, int filter) {

this.handlers = new int[Texture3D.HANDLERS\_COUNT];

GLES32.glGenTextures(1, this.handlers, 0);

GLES32.glBindTexture(GLES32.GL\_TEXTURE\_CUBE\_MAP, this.handlers[Texture3D.HANDLER\_INDEX\_ID]);

final BitmapFactory.Options options = new BitmapFactory.Options();

options.inScaled = false;

int[] cubeTargets = {

GLES32.GL\_TEXTURE\_CUBE\_MAP\_POSITIVE\_X, // Right

GLES32.GL\_TEXTURE\_CUBE\_MAP\_NEGATIVE\_X, // Left

GLES32.GL\_TEXTURE\_CUBE\_MAP\_POSITIVE\_Y, // Top

GLES32.GL\_TEXTURE\_CUBE\_MAP\_NEGATIVE\_Y, // Bottom

GLES32.GL\_TEXTURE\_CUBE\_MAP\_POSITIVE\_Z, // Front

GLES32.GL\_TEXTURE\_CUBE\_MAP\_NEGATIVE\_Z // Back

};

for (int i = 0; i < 6; ++i) {

final Bitmap bitmap = BitmapFactory.decodeResource(context.getResources(), resourceIds[i], options);

GLUtils.texImage2D(cubeTargets[i], 0, bitmap, 0);

bitmap.recycle();

}

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_CUBE\_MAP, GLES32.GL\_TEXTURE\_WRAP\_S, wrap);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_CUBE\_MAP, GLES32.GL\_TEXTURE\_WRAP\_T, wrap);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_CUBE\_MAP, GLES32.GL\_TEXTURE\_WRAP\_R, wrap);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_CUBE\_MAP, GLES32.GL\_TEXTURE\_MIN\_FILTER, filter);

GLES32.glTexParameteri(GLES32.GL\_TEXTURE\_CUBE\_MAP, GLES32.GL\_TEXTURE\_MAG\_FILTER, filter);

GLES32.glBindTexture(GLES32.GL\_TEXTURE\_CUBE\_MAP, 0);

}

public int getId() {

return this.handlers[Texture3D.HANDLER\_INDEX\_ID];

}

}

**Vector3.java**

package com.labwork.texturesexample.core.general;

public final class Vector3 {

private float x;

private float y;

private float z;

public Vector3(float x, float y, float z) {

this.x = x;

this.y = y;

this.z = z;

}

public float getX() {

return this.x;

}

public void setX(float value) {

this.x = value;

}

public float getY() {

return this.y;

}

public void setY(float value) {

this.y = value;

}

public float getZ() {

return this.z;

}

public void setZ(float value) {

this.z = value;

}

public void setXYZ(float x, float y, float z) {

this.x = x;

this.y = y;

this.z = z;

}

public float getMagnitude() {

return (float) Math.sqrt(this.x \* this.x + this.y \* this.y + this.z \* this.z);

}

public static float dot(Vector3 a, Vector3 b) {

return a.x \* b.x + a.y \* b.y + a.z \* b.z;

}

public static void add(Vector3 a, Vector3 b, Vector3 output) {

output.x = a.x + b.x;

output.y = a.y + b.y;

output.z = a.z + b.z;

}

public static void subtract(Vector3 a, Vector3 b, Vector3 output) {

output.x = a.x - b.x;

output.y = a.y - b.y;

output.z = a.z - b.z;

}

public static void multiply(Vector3 a, float scalar, Vector3 output) {

output.x = a.x \* scalar;

output.y = a.y \* scalar;

output.z = a.z \* scalar;

}

public static void cross(Vector3 a, Vector3 b, Vector3 output) {

output.x = a.y \* b.z - a.z \* b.y;

output.y = a.z \* b.x - a.x \* b.z;

output.z = a.x \* b.y - a.y \* b.x;

}

public static void normalize(Vector3 a, Vector3 output) {

float magnitude = (float) Math.sqrt(a.x \* a.x + a.y \* a.y + a.z \* a.z);

if (magnitude == 0) {

output.x = 0;

output.y = 0;

output.z = 0;

} else {

output.x = a.x / magnitude;

output.y = a.y / magnitude;

output.z = a.z / magnitude;

}

}

}

**DynamicLightControllerComponent.java**

package com.labwork.texturesexample.demo.components;

import android.view.View;

import android.view.MotionEvent;

import android.widget.Button;

import android.widget.RelativeLayout;

import android.widget.RelativeLayout.LayoutParams;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Vector3;

import com.labwork.texturesexample.core.components.common.Component;

import com.labwork.texturesexample.core.components.concrete.TransformComponent;

public final class DynamicLightControllerComponent extends Component {

private static final float MOVEMENT\_SPEED = 1.0f;

private TransformComponent transform;

private boolean isMovingLeft;

private boolean isMovingRight;

private boolean isMovingForward;

private boolean isMovingBackward;

private boolean isMovingUp;

private boolean isMovingDown;

private final Button buttonMoveLeft;

private final Button buttonMoveRight;

private final Button buttonMoveForward;

private final Button buttonMoveBackward;

private final Button buttonMoveUp;

private final Button buttonMoveDown;

public DynamicLightControllerComponent(Entity entity, Button buttonMoveForward, Button buttonMoveBackward, Button buttonMoveLeft, Button buttonMoveRight, Button buttonMoveUp, Button buttonMoveDown) {

super(entity);

int spacing = 10;

int leftOffset = 50;

int rightOffset = 50;

int buttonSize = 125;

int bottomOffset = 150;

float textSize = 30.0f;

buttonMoveLeft.setVisibility(View.INVISIBLE);

buttonMoveRight.setVisibility(View.INVISIBLE);

buttonMoveForward.setVisibility(View.INVISIBLE);

buttonMoveBackward.setVisibility(View.INVISIBLE);

buttonMoveUp.setVisibility(View.INVISIBLE);

buttonMoveDown.setVisibility(View.INVISIBLE);

this.buttonMoveLeft = buttonMoveLeft;

buttonMoveLeft.setId(View.generateViewId());

buttonMoveLeft.setPadding(0, 0, 0, 0);

buttonMoveLeft.setText("←");

buttonMoveLeft.setTextSize(textSize);

LayoutParams paramsMoveLeft = new LayoutParams(buttonSize, buttonSize);

paramsMoveLeft.addRule(RelativeLayout.ALIGN\_PARENT\_BOTTOM);

paramsMoveLeft.addRule(RelativeLayout.ALIGN\_PARENT\_LEFT);

paramsMoveLeft.leftMargin = leftOffset;

paramsMoveLeft.bottomMargin = bottomOffset;

buttonMoveLeft.setLayoutParams(paramsMoveLeft);

buttonMoveLeft.setOnTouchListener(this::handleMoveLeftButtonTouch);

this.buttonMoveBackward = buttonMoveBackward;

buttonMoveBackward.setId(View.generateViewId());

buttonMoveBackward.setPadding(0, 0, 0, 0);

buttonMoveBackward.setText("↓");

buttonMoveBackward.setTextSize(textSize);

LayoutParams paramsMoveDown = new LayoutParams(buttonSize, buttonSize);

paramsMoveDown.addRule(RelativeLayout.RIGHT\_OF, buttonMoveLeft.getId());

paramsMoveDown.addRule(RelativeLayout.ALIGN\_PARENT\_BOTTOM);

paramsMoveDown.leftMargin = spacing;

paramsMoveDown.bottomMargin = bottomOffset;

buttonMoveBackward.setLayoutParams(paramsMoveDown);

buttonMoveBackward.setOnTouchListener(this::handleMoveBackwardButtonTouch);

this.buttonMoveForward = buttonMoveForward;

buttonMoveForward.setId(View.generateViewId());

buttonMoveForward.setPadding(0, 0, 0, 0);

buttonMoveForward.setText("↑");

buttonMoveForward.setTextSize(textSize);

LayoutParams paramsMoveUp = new LayoutParams(buttonSize, buttonSize);

paramsMoveUp.addRule(RelativeLayout.ABOVE, buttonMoveBackward.getId());

paramsMoveUp.addRule(RelativeLayout.ALIGN\_LEFT, buttonMoveBackward.getId());

paramsMoveUp.bottomMargin = spacing;

buttonMoveForward.setLayoutParams(paramsMoveUp);

buttonMoveForward.setOnTouchListener(this::handleMoveForwardButtonTouch);

this.buttonMoveRight = buttonMoveRight;

buttonMoveRight.setId(View.generateViewId());

buttonMoveRight.setPadding(0, 0, 0, 0);

buttonMoveRight.setText("→");

buttonMoveRight.setTextSize(textSize);

LayoutParams paramsMoveRight = new LayoutParams(buttonSize, buttonSize);

paramsMoveRight.addRule(RelativeLayout.RIGHT\_OF, buttonMoveBackward.getId());

paramsMoveRight.addRule(RelativeLayout.ALIGN\_TOP, buttonMoveBackward.getId());

paramsMoveRight.leftMargin = spacing;

buttonMoveRight.setLayoutParams(paramsMoveRight);

buttonMoveRight.setOnTouchListener(this::handleMoveRightButtonTouch);

this.buttonMoveDown = buttonMoveDown;

buttonMoveDown.setId(View.generateViewId());

buttonMoveDown.setPadding(0, 0, 0, 0);

buttonMoveDown.setText("↓");

buttonMoveDown.setTextSize(textSize);

LayoutParams paramsMoveDownRight = new LayoutParams(buttonSize, buttonSize);

paramsMoveDownRight.addRule(RelativeLayout.ALIGN\_PARENT\_BOTTOM);

paramsMoveDownRight.addRule(RelativeLayout.ALIGN\_PARENT\_RIGHT);

paramsMoveDownRight.rightMargin = rightOffset;

paramsMoveDownRight.bottomMargin = bottomOffset;

buttonMoveDown.setLayoutParams(paramsMoveDownRight);

buttonMoveDown.setOnTouchListener(this::handleMoveDownButtonTouch);

this.buttonMoveUp = buttonMoveUp;

buttonMoveUp.setId(View.generateViewId());

buttonMoveUp.setPadding(0, 0, 0, 0);

buttonMoveUp.setText("↑");

buttonMoveUp.setTextSize(textSize);

LayoutParams paramsMoveUpRight = new LayoutParams(buttonSize, buttonSize);

paramsMoveUpRight.addRule(RelativeLayout.ABOVE, buttonMoveDown.getId());

paramsMoveUpRight.addRule(RelativeLayout.ALIGN\_LEFT, buttonMoveDown.getId());

paramsMoveUpRight.bottomMargin = spacing;

buttonMoveUp.setLayoutParams(paramsMoveUpRight);

buttonMoveUp.setOnTouchListener(this::handleMoveUpButtonTouch);

Framework.getInstance().getViewport().register(buttonMoveLeft);

Framework.getInstance().getViewport().register(buttonMoveRight);

Framework.getInstance().getViewport().register(buttonMoveForward);

Framework.getInstance().getViewport().register(buttonMoveBackward);

Framework.getInstance().getViewport().register(buttonMoveUp);

Framework.getInstance().getViewport().register(buttonMoveDown);

}

private boolean handleMoveForwardButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingForward = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingForward = false;

return true;

default:

return false;

}

}

private boolean handleMoveBackwardButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingBackward = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingBackward = false;

return true;

default:

return false;

}

}

private boolean handleMoveLeftButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingLeft = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingLeft = false;

return true;

default:

return false;

}

}

private boolean handleMoveRightButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingRight = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingRight = false;

return true;

default:

return false;

}

}

private boolean handleMoveUpButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingUp = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingUp = false;

return true;

default:

return false;

}

}

private boolean handleMoveDownButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingDown = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingDown = false;

return true;

default:

return false;

}

}

@Override

public void onStart() {

this.buttonMoveLeft.setVisibility(View.VISIBLE);

this.buttonMoveRight.setVisibility(View.VISIBLE);

this.buttonMoveForward.setVisibility(View.VISIBLE);

this.buttonMoveBackward.setVisibility(View.VISIBLE);

this.buttonMoveUp.setVisibility(View.VISIBLE);

this.buttonMoveDown.setVisibility(View.VISIBLE);

this.transform = super.getEntity().getComponent(TransformComponent.class);

}

@Override

public void onUpdate(float deltaTime) {

Vector3 position = this.transform.getPosition();

float moveSpeed = DynamicLightControllerComponent.MOVEMENT\_SPEED \* deltaTime;

if (this.isMovingForward) {

position.setZ(position.getZ() + moveSpeed);

}

if (this.isMovingBackward) {

position.setZ(position.getZ() - moveSpeed);

}

if (this.isMovingLeft) {

position.setX(position.getX() + moveSpeed);

}

if (this.isMovingRight) {

position.setX(position.getX() - moveSpeed);

}

if (this.isMovingUp) {

position.setY(position.getY() + moveSpeed);

}

if (this.isMovingDown) {

position.setY(position.getY() - moveSpeed);

}

}

@Override

public void onDestroy() {

this.buttonMoveLeft.setVisibility(View.INVISIBLE);

this.buttonMoveRight.setVisibility(View.INVISIBLE);

this.buttonMoveForward.setVisibility(View.INVISIBLE);

this.buttonMoveBackward.setVisibility(View.INVISIBLE);

this.buttonMoveUp.setVisibility(View.INVISIBLE);

this.buttonMoveDown.setVisibility(View.INVISIBLE);

}

}

**NoClipControllerComponent.java**

package com.labwork.texturesexample.demo.components;

import android.view.View;

import android.view.MotionEvent;

import android.widget.Button;

import android.widget.RelativeLayout;

import android.widget.RelativeLayout.LayoutParams;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Vector3;

import com.labwork.texturesexample.core.components.common.Component;

import com.labwork.texturesexample.core.components.concrete.TransformComponent;

public final class NoClipControllerComponent extends Component {

private static final float MOVEMENT\_SPEED = 1.0f;

private static final float ROTATION\_SPEED = 45.0f;

private final Button buttonMoveLeft;

private final Button buttonMoveRight;

private final Button buttonMoveForward;

private final Button buttonMoveBackward;

private final Button buttonRotateUp;

private final Button buttonRotateDown;

private final Button buttonRotateLeft;

private final Button buttonRotateRight;

private final Vector3 tempVector = new Vector3(0, 0, 0);

private final Vector3 moveDirection = new Vector3(0, 0, 0);

private TransformComponent transform;

private boolean isMovingLeft;

private boolean isMovingRight;

private boolean isMovingForward;

private boolean isMovingBackward;

private boolean isRotatingUp;

private boolean isRotatingDown;

private boolean isRotatingLeft;

private boolean isRotatingRight;

public NoClipControllerComponent(Entity entity, Button buttonMoveForward, Button buttonMoveBackward, Button buttonMoveLeft, Button buttonMoveRight, Button buttonRotateUp, Button buttonRotateDown, Button buttonRotateLeft, Button buttonRotateRight) {

super(entity);

int spacing = 10;

int leftOffset = 50;

int rightOffset = 50;

int buttonSize = 125;

int bottomOffset = 150;

float textSize = 30.0f;

buttonMoveLeft.setVisibility(View.INVISIBLE);

buttonMoveRight.setVisibility(View.INVISIBLE);

buttonMoveForward.setVisibility(View.INVISIBLE);

buttonMoveBackward.setVisibility(View.INVISIBLE);

buttonRotateUp.setVisibility(View.INVISIBLE);

buttonRotateDown.setVisibility(View.INVISIBLE);

buttonRotateLeft.setVisibility(View.INVISIBLE);

buttonRotateRight.setVisibility(View.INVISIBLE);

this.buttonMoveLeft = buttonMoveLeft;

buttonMoveLeft.setId(View.generateViewId());

buttonMoveLeft.setPadding(0, 0, 0, 0);

buttonMoveLeft.setText("←");

buttonMoveLeft.setTextSize(textSize);

LayoutParams paramsMoveLeft = new LayoutParams(buttonSize, buttonSize);

paramsMoveLeft.addRule(RelativeLayout.ALIGN\_PARENT\_BOTTOM);

paramsMoveLeft.addRule(RelativeLayout.ALIGN\_PARENT\_LEFT);

paramsMoveLeft.leftMargin = leftOffset;

paramsMoveLeft.bottomMargin = bottomOffset;

buttonMoveLeft.setLayoutParams(paramsMoveLeft);

buttonMoveLeft.setOnTouchListener(this::handleMoveLeftButtonTouch);

this.buttonMoveBackward = buttonMoveBackward;

buttonMoveBackward.setId(View.generateViewId());

buttonMoveBackward.setPadding(0, 0, 0, 0);

buttonMoveBackward.setText("↓");

buttonMoveBackward.setTextSize(textSize);

LayoutParams paramsMoveDown = new LayoutParams(buttonSize, buttonSize);

paramsMoveDown.addRule(RelativeLayout.RIGHT\_OF, buttonMoveLeft.getId());

paramsMoveDown.addRule(RelativeLayout.ALIGN\_PARENT\_BOTTOM);

paramsMoveDown.leftMargin = spacing;

paramsMoveDown.bottomMargin = bottomOffset;

buttonMoveBackward.setLayoutParams(paramsMoveDown);

buttonMoveBackward.setOnTouchListener(this::handleMoveBackwardButtonTouch);

this.buttonMoveForward = buttonMoveForward;

buttonMoveForward.setId(View.generateViewId());

buttonMoveForward.setPadding(0, 0, 0, 0);

buttonMoveForward.setText("↑");

buttonMoveForward.setTextSize(textSize);

LayoutParams paramsMoveUp = new LayoutParams(buttonSize, buttonSize);

paramsMoveUp.addRule(RelativeLayout.ABOVE, buttonMoveBackward.getId());

paramsMoveUp.addRule(RelativeLayout.ALIGN\_LEFT, buttonMoveBackward.getId());

paramsMoveUp.bottomMargin = spacing;

buttonMoveForward.setLayoutParams(paramsMoveUp);

buttonMoveForward.setOnTouchListener(this::handleMoveForwardButtonTouch);

this.buttonMoveRight = buttonMoveRight;

buttonMoveRight.setId(View.generateViewId());

buttonMoveRight.setPadding(0, 0, 0, 0);

buttonMoveRight.setText("→");

buttonMoveRight.setTextSize(textSize);

LayoutParams paramsMoveRight = new LayoutParams(buttonSize, buttonSize);

paramsMoveRight.addRule(RelativeLayout.RIGHT\_OF, buttonMoveBackward.getId());

paramsMoveRight.addRule(RelativeLayout.ALIGN\_TOP, buttonMoveBackward.getId());

paramsMoveRight.leftMargin = spacing;

buttonMoveRight.setLayoutParams(paramsMoveRight);

buttonMoveRight.setOnTouchListener(this::handleMoveRightButtonTouch);

this.buttonRotateRight = buttonRotateRight;

buttonRotateRight.setId(View.generateViewId());

buttonRotateRight.setPadding(0, 0, 0, 0);

buttonRotateRight.setText("→");

buttonRotateRight.setTextSize(textSize);

LayoutParams paramsRotateRight = new LayoutParams(buttonSize, buttonSize);

paramsRotateRight.addRule(RelativeLayout.ALIGN\_PARENT\_BOTTOM);

paramsRotateRight.addRule(RelativeLayout.ALIGN\_PARENT\_RIGHT);

paramsRotateRight.rightMargin = rightOffset;

paramsRotateRight.bottomMargin = bottomOffset;

buttonRotateRight.setLayoutParams(paramsRotateRight);

buttonRotateRight.setOnTouchListener(this::handleRotateRightButtonTouch);

this.buttonRotateDown = buttonRotateDown;

buttonRotateDown.setId(View.generateViewId());

buttonRotateDown.setPadding(0, 0, 0, 0);

buttonRotateDown.setText("↓");

buttonRotateDown.setTextSize(textSize);

LayoutParams paramsRotateDown = new LayoutParams(buttonSize, buttonSize);

paramsRotateDown.addRule(RelativeLayout.LEFT\_OF, buttonRotateRight.getId());

paramsRotateDown.addRule(RelativeLayout.ALIGN\_PARENT\_BOTTOM);

paramsRotateDown.rightMargin = spacing;

paramsRotateDown.bottomMargin = bottomOffset;

buttonRotateDown.setLayoutParams(paramsRotateDown);

buttonRotateDown.setOnTouchListener(this::handleRotateDownButtonTouch);

this.buttonRotateLeft = buttonRotateLeft;

buttonRotateLeft.setId(View.generateViewId());

buttonRotateLeft.setPadding(0, 0, 0, 0);

buttonRotateLeft.setText("←");

buttonRotateLeft.setTextSize(textSize);

LayoutParams paramsRotateLeft = new LayoutParams(buttonSize, buttonSize);

paramsRotateLeft.addRule(RelativeLayout.LEFT\_OF, buttonRotateDown.getId());

paramsRotateLeft.addRule(RelativeLayout.ALIGN\_TOP, buttonRotateDown.getId());

paramsRotateLeft.rightMargin = spacing;

buttonRotateLeft.setLayoutParams(paramsRotateLeft);

buttonRotateLeft.setOnTouchListener(this::handleRotateLeftButtonTouch);

this.buttonRotateUp = buttonRotateUp;

buttonRotateUp.setId(View.generateViewId());

buttonRotateUp.setPadding(0, 0, 0, 0);

buttonRotateUp.setText("↑");

buttonRotateUp.setTextSize(textSize);

LayoutParams paramsRotateUp = new LayoutParams(buttonSize, buttonSize);

paramsRotateUp.addRule(RelativeLayout.ABOVE, buttonRotateDown.getId());

paramsRotateUp.addRule(RelativeLayout.ALIGN\_LEFT, buttonRotateDown.getId());

paramsRotateUp.bottomMargin = spacing;

buttonRotateUp.setLayoutParams(paramsRotateUp);

buttonRotateUp.setOnTouchListener(this::handleRotateUpButtonTouch);

Framework.getInstance().getViewport().register(buttonMoveLeft);

Framework.getInstance().getViewport().register(buttonMoveRight);

Framework.getInstance().getViewport().register(buttonMoveForward);

Framework.getInstance().getViewport().register(buttonMoveBackward);

Framework.getInstance().getViewport().register(buttonRotateUp);

Framework.getInstance().getViewport().register(buttonRotateDown);

Framework.getInstance().getViewport().register(buttonRotateLeft);

Framework.getInstance().getViewport().register(buttonRotateRight);

}

private boolean handleMoveForwardButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingForward = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingForward = false;

return true;

default:

return false;

}

}

private boolean handleMoveBackwardButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingBackward = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingBackward = false;

return true;

default:

return false;

}

}

private boolean handleMoveLeftButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingLeft = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingLeft = false;

return true;

default:

return false;

}

}

private boolean handleMoveRightButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isMovingRight = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isMovingRight = false;

return true;

default:

return false;

}

}

private boolean handleRotateUpButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isRotatingUp = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isRotatingUp = false;

return true;

default:

return false;

}

}

private boolean handleRotateDownButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isRotatingDown = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isRotatingDown = false;

return true;

default:

return false;

}

}

private boolean handleRotateLeftButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isRotatingLeft = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isRotatingLeft = false;

return true;

default:

return false;

}

}

private boolean handleRotateRightButtonTouch(View view, MotionEvent event) {

switch (event.getAction()) {

case MotionEvent.ACTION\_DOWN:

this.isRotatingRight = true;

return true;

case MotionEvent.ACTION\_UP:

case MotionEvent.ACTION\_CANCEL:

this.isRotatingRight = false;

return true;

default:

return false;

}

}

@Override

public void onStart() {

this.buttonMoveLeft.setVisibility(View.VISIBLE);

this.buttonMoveRight.setVisibility(View.VISIBLE);

this.buttonMoveForward.setVisibility(View.VISIBLE);

this.buttonMoveBackward.setVisibility(View.VISIBLE);

this.buttonRotateUp.setVisibility(View.VISIBLE);

this.buttonRotateDown.setVisibility(View.VISIBLE);

this.buttonRotateLeft.setVisibility(View.VISIBLE);

this.buttonRotateRight.setVisibility(View.VISIBLE);

this.transform = super.getEntity().getComponent(TransformComponent.class);

}

@Override

public void onUpdate(float deltaTime) {

Vector3 position = this.transform.getPosition();

Vector3 rotation = this.transform.getRotation();

float moveSpeed = NoClipControllerComponent.MOVEMENT\_SPEED \* deltaTime;

float rotateSpeed = NoClipControllerComponent.ROTATION\_SPEED \* deltaTime;

if (this.isRotatingUp) {

rotation.setX(rotation.getX() - rotateSpeed);

}

if (this.isRotatingDown) {

rotation.setX(rotation.getX() + rotateSpeed);

}

if (this.isRotatingLeft) {

rotation.setY(rotation.getY() + rotateSpeed);

}

if (this.isRotatingRight) {

rotation.setY(rotation.getY() - rotateSpeed);

}

this.moveDirection.setXYZ(0, 0, 0);

if (this.isMovingLeft) {

Vector3.add(this.moveDirection, this.transform.getRight(), this.moveDirection);

}

if (this.isMovingRight) {

Vector3.subtract(this.moveDirection, this.transform.getRight(), this.moveDirection);

}

if (this.isMovingForward) {

Vector3.add(this.moveDirection, this.transform.getForward(), this.moveDirection);

}

if (this.isMovingBackward) {

Vector3.subtract(this.moveDirection, this.transform.getForward(), this.moveDirection);

}

if (this.moveDirection.getMagnitude() > 0) {

Vector3.normalize(this.moveDirection, this.tempVector);

Vector3.multiply(this.tempVector, moveSpeed, this.moveDirection);

position.setX(position.getX() + this.moveDirection.getX());

position.setY(position.getY() + this.moveDirection.getY());

position.setZ(position.getZ() + this.moveDirection.getZ());

}

}

@Override

public void onDestroy() {

this.buttonMoveLeft.setVisibility(View.INVISIBLE);

this.buttonMoveRight.setVisibility(View.INVISIBLE);

this.buttonMoveForward.setVisibility(View.INVISIBLE);

this.buttonMoveBackward.setVisibility(View.INVISIBLE);

this.buttonRotateUp.setVisibility(View.INVISIBLE);

this.buttonRotateDown.setVisibility(View.INVISIBLE);

this.buttonRotateLeft.setVisibility(View.INVISIBLE);

this.buttonRotateRight.setVisibility(View.INVISIBLE);

}

}

**Standalone.java**

package com.labwork.texturesexample.demo.shaders;

public final class Standalone {

public static final String SHADER\_OPAQUE\_VERT\_SOURCE =

"#version 300 es\n" +

"in vec3 aVertexColorRGB;\n" +

"in vec3 aVertexNormalLocal;\n" +

"in vec3 aVertexPositionLocal;\n" +

"in vec2 aVertexTextureCoordinate;\n" +

"uniform mat4 uMatrixView;\n" +

"uniform mat4 uMatrixModel;\n" +

"uniform mat4 uMatrixProjection;\n" +

"out vec3 vVertexColorRGB;\n" +

"out vec2 vVertexTextureCoordinate;\n" +

"void main() {\n" +

" gl\_Position = uMatrixProjection \* uMatrixView \* uMatrixModel \* vec4(aVertexPositionLocal, 1.0);\n" +

" vVertexColorRGB = aVertexColorRGB;\n" +

" vVertexTextureCoordinate = aVertexTextureCoordinate;\n" +

"}\n";

public static final String SHADER\_OPAQUE\_FRAG\_SOURCE =

"#version 300 es\n" +

"precision mediump float;\n" +

"in vec3 vVertexColorRGB;\n" +

"in vec2 vVertexTextureCoordinate;\n" +

"uniform vec4 uMaterialColorRGBA;\n" +

"uniform sampler2D uTextureAlbedo;\n" +

"out vec4 outFragmentColor;\n" +

"void main() {\n" +

" outFragmentColor = texture(uTextureAlbedo, vVertexTextureCoordinate);\n" +

"}\n";

public static final String SHADER\_SKYBOX\_VERT\_SOURCE =

"#version 300 es\n" +

"in vec3 aVertexColorRGB;\n" +

"in vec3 aVertexNormalLocal;\n" +

"in vec3 aVertexPositionLocal;\n" +

"in vec2 aVertexTextureCoordinate;\n" +

"uniform mat4 uMatrixView;\n" +

"uniform mat4 uMatrixModel;\n" +

"uniform mat4 uMatrixProjection;\n" +

"out vec3 vTextureCoordinate;\n" +

"void main() {\n" +

" mat4 viewNoTranslation = mat4(mat3(uMatrixView));\n" +

" gl\_Position = uMatrixProjection \* viewNoTranslation \* uMatrixModel \* vec4(aVertexPositionLocal, 1.0);\n" +

" vTextureCoordinate = aVertexPositionLocal;\n" +

"}\n";

public static final String SHADER\_SKYBOX\_FRAG\_SOURCE =

"#version 300 es\n" +

"precision mediump float;\n" +

"in vec3 vTextureCoordinate;\n" +

"uniform samplerCube uCubeTexture;\n" +

"out vec4 outFragmentColor;\n" +

"void main() {\n" +

" outFragmentColor = texture(uCubeTexture, vTextureCoordinate);\n" +

"}\n";

}

**RenderFeature.java**

package com.labwork.texturesexample.rendering.features.common;

import java.util.List;

import com.labwork.texturesexample.core.general.Shader;

import com.labwork.texturesexample.core.general.Entity;

public abstract class RenderFeature {

protected Shader shader;

public RenderFeature(Shader shader) {

this.shader = shader;

}

public abstract void execute(List<Entity> dispatchedEntities);

}

**OpaqueRenderPass.java**

package com.labwork.texturesexample.rendering.features.concrete;

import java.util.List;

import android.opengl.GLES32;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Shader;

import com.labwork.texturesexample.rendering.features.common.RenderFeature;

import com.labwork.texturesexample.core.components.concrete.CameraComponent;

import com.labwork.texturesexample.core.components.concrete.OpaqueRenderingComponent;

public final class OpaqueRenderFeature extends RenderFeature {

public OpaqueRenderFeature(Shader shader) {

super(shader);

}

@Override

public final void execute(List<Entity> dispatchedEntities) {

GLES32.glEnable(GLES32.GL\_DEPTH\_TEST);

GLES32.glUseProgram(super.shader.getId());

GLES32.glActiveTexture(GLES32.GL\_TEXTURE0);

CameraComponent camera = Framework.getInstance().getScene().getCamera();

GLES32.glUniformMatrix4fv(super.shader.getVariableHandler("uMatrixView"), 1, false, camera.getMatrixView(), 0);

GLES32.glUniformMatrix4fv(super.shader.getVariableHandler("uMatrixProjection"), 1, false, camera.getMatrixProjection(), 0);

for (Entity entity: dispatchedEntities) {

OpaqueRenderingComponent rendering = entity.getComponent(OpaqueRenderingComponent.class);

if (rendering == null)

continue;

if (rendering.getMaterial().getShader().getRenderFeature() == OpaqueRenderFeature.class) {

rendering.render();

}

}

GLES32.glUseProgram(0);

GLES32.glDisable(GLES32.GL\_DEPTH\_TEST);

}

}

**SkyboxRednerFetature.java**

package com.labwork.texturesexample.rendering.features.concrete;

import java.util.List;

import android.opengl.GLES32;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Shader;

import com.labwork.texturesexample.rendering.features.common.RenderFeature;

import com.labwork.texturesexample.core.components.concrete.CameraComponent;

import com.labwork.texturesexample.core.components.concrete.SkyboxRenderingComponent;

public final class SkyboxRenderFeature extends RenderFeature {

public SkyboxRenderFeature(Shader shader) {

super(shader);

}

@Override

public final void execute(List<Entity> dispatchedEntities) {

GLES32.glClear(GLES32.GL\_COLOR\_BUFFER\_BIT | GLES32.GL\_DEPTH\_BUFFER\_BIT);

GLES32.glDepthMask(false);

GLES32.glUseProgram(super.shader.getId());

GLES32.glActiveTexture(GLES32.GL\_TEXTURE0);

CameraComponent camera = Framework.getInstance().getScene().getCamera();

GLES32.glUniformMatrix4fv(super.shader.getVariableHandler("uMatrixView"), 1, false, camera.getMatrixView(), 0);

GLES32.glUniformMatrix4fv(super.shader.getVariableHandler("uMatrixProjection"), 1, false, camera.getMatrixProjection(), 0);

SkyboxRenderingComponent skybox = Framework.getInstance().getScene().getSkybox();

if (skybox != null) {

skybox.render();

}

GLES32.glUseProgram(0);

GLES32.glDepthMask(true);

}

}

**RenderProgrammable.java**

package com.labwork.texturesexample.rendering.renderer.common;

import android.opengl.GLSurfaceView.Renderer;

import javax.microedition.khronos.egl.EGLConfig;

import javax.microedition.khronos.opengles.GL10;

import com.labwork.texturesexample.core.general.Scene;

import com.labwork.texturesexample.rendering.features.common.RenderFeature;

public interface RendererProgrammable extends Renderer {

void onDrawFrame(GL10 unused);

void onSurfaceCreated(GL10 unused, EGLConfig config);

void onSurfaceChanged(GL10 unused, int width, int height);

void loadScene(Scene scene);

void registerRenderFeature(RenderFeature feature);

}

**ForwardRenderer.java**

package com.labwork.texturesexample.rendering.renderer.concrete;

import java.util.List;

import java.util.ArrayList;

import javax.microedition.khronos.egl.EGLConfig;

import javax.microedition.khronos.opengles.GL10;

import android.opengl.GLES32;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Scene;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.rendering.features.common.RenderFeature;

import com.labwork.texturesexample.rendering.renderer.common.RendererProgrammable;

public final class ForwardRenderer implements RendererProgrammable {

private final List<RenderFeature> features;

private final List<Entity> dispatchedEntities;

private final Runnable initializationCallback;

private float deltaTime;

private float timestampCurrent;

private float timestampPrevious;

public ForwardRenderer(Runnable initializationCallback) {

this.features = new ArrayList<>();

this.dispatchedEntities = new ArrayList<>();

this.initializationCallback = initializationCallback;

}

public void onDrawFrame(GL10 unused) {

this.timestampCurrent = System.nanoTime();

this.deltaTime = (this.timestampCurrent - this.timestampPrevious) / 1\_000\_000\_000.0f;

this.timestampPrevious = this.timestampCurrent;

if (this.deltaTime > 0.95f) {

this.deltaTime = 0.95f;

}

if (Framework.getInstance().getScene() == null)

return;

this.dispatchedEntities.clear();

List<Entity> entities = Framework.getInstance().getScene().getEntities();

for (Entity entity : entities) {

if (entity.getIsActive()) {

entity.onUpdate(this.deltaTime);

this.dispatchedEntities.add(entity);

}

}

for (RenderFeature feature : this.features)

feature.execute(this.dispatchedEntities);

}

public void onSurfaceCreated(GL10 unused, EGLConfig config) {

this.initializationCallback.run();

this.timestampPrevious = System.nanoTime();

}

public void onSurfaceChanged(GL10 unused, int width, int height) {

GLES32.glViewport(0, 0, width, height);

}

public void loadScene(Scene scene) {

List<Entity> entities = Framework.getInstance().getScene().getEntities();

for (Entity entity : entities)

entity.onStart();

}

public void registerRenderFeature(RenderFeature feature) {

this.features.add(feature);

}

}

**ViewportConfigurable.java**

package com.labwork.texturesexample.rendering.viewport.common;

import android.view.View;

import android.widget.RelativeLayout;

import android.opengl.GLSurfaceView;

import com.labwork.texturesexample.rendering.renderer.common.RendererProgrammable;

public interface ViewportConfigurable {

RelativeLayout getLayout();

GLSurfaceView getSurfaceView();

void register(View view);

void initialize(RendererProgrammable renderer);

}

**Viewport.java**

package com.labwork.texturesexample.rendering.viewport.concrete;

import android.content.Context;

import android.opengl.GLSurfaceView;

import android.view.View;

import android.widget.RelativeLayout;

import android.widget.RelativeLayout.LayoutParams;

import com.labwork.texturesexample.rendering.renderer.common.RendererProgrammable;

import com.labwork.texturesexample.rendering.viewport.common.ViewportConfigurable;

public final class Viewport extends GLSurfaceView implements ViewportConfigurable {

private final RelativeLayout layout;

public Viewport(Context context) {

super(context);

super.setEGLContextClientVersion(3);

this.layout = new RelativeLayout(context);

this.layout.addView(this, new LayoutParams(LayoutParams.MATCH\_PARENT, LayoutParams.MATCH\_PARENT));

}

public RelativeLayout getLayout() {

return this.layout;

}

public GLSurfaceView getSurfaceView() {

return this;

}

public void register(View view) {

this.layout.post(() -> {

this.layout.addView(view);

});

}

public void initialize(RendererProgrammable renderer) {

super.setFocusable(true);

super.setRenderer(renderer);

super.setFocusableInTouchMode(true);

super.setRenderMode(GLSurfaceView.RENDERMODE\_CONTINUOUSLY);

}

}

**Framework.java**

package com.labwork.texturesexample.runtime;

import android.opengl.GLSurfaceView;

import com.labwork.texturesexample.core.general.Scene;

import com.labwork.texturesexample.rendering.renderer.common.RendererProgrammable;

import com.labwork.texturesexample.rendering.viewport.common.ViewportConfigurable;

public final class Framework {

private static final Framework INSTANCE = new Framework();

private Scene scene;

private GLSurfaceView surfaceView;

private ViewportConfigurable viewport;

private RendererProgrammable renderer;

private Framework() { }

public static Framework getInstance() {

return Framework.INSTANCE;

}

public Scene getScene() {

return this.scene;

}

public GLSurfaceView getSurfaceView() {

return this.surfaceView;

}

public ViewportConfigurable getViewport() {

return this.viewport;

}

public RendererProgrammable getRenderer() {

return this.renderer;

}

public void loadScene(Scene scene) {

if (this.scene != null)

this.scene.onUnloaded();

this.scene = scene;

this.renderer.loadScene(scene);

}

public void initialize(RendererProgrammable renderer, ViewportConfigurable viewport) {

viewport.initialize(renderer);

this.renderer = renderer;

this.viewport = viewport;

this.surfaceView = viewport.getSurfaceView();

}

}

**MainActivity.java**

package com.labwork.texturesexample;

import android.os.Bundle;

import android.view.Menu;

import android.view.MenuItem;

import android.widget.Button;

import android.opengl.GLES32;

import androidx.appcompat.app.AppCompatActivity;

import com.labwork.texturesexample.runtime.Framework;

import com.labwork.texturesexample.core.general.Mesh;

import com.labwork.texturesexample.core.general.Color;

import com.labwork.texturesexample.core.general.Scene;

import com.labwork.texturesexample.core.general.Entity;

import com.labwork.texturesexample.core.general.Shader;

import com.labwork.texturesexample.core.general.Texture2D;

import com.labwork.texturesexample.core.general.Texture3D;

import com.labwork.texturesexample.core.general.Material;

import com.labwork.texturesexample.demo.components.NoClipControllerComponent;

import com.labwork.texturesexample.core.components.concrete.TransformComponent;

import com.labwork.texturesexample.core.components.concrete.SkyboxRenderingComponent;

import com.labwork.texturesexample.core.components.concrete.OpaqueRenderingComponent;

import com.labwork.texturesexample.core.components.concrete.CameraPerspectiveComponent;

import com.labwork.texturesexample.demo.shaders.Standalone;

import com.labwork.texturesexample.rendering.renderer.concrete.ForwardRenderer;

import com.labwork.texturesexample.rendering.renderer.common.RendererProgrammable;

import com.labwork.texturesexample.rendering.features.concrete.OpaqueRenderFeature;

import com.labwork.texturesexample.rendering.features.concrete.SkyboxRenderFeature;

import com.labwork.texturesexample.rendering.viewport.concrete.Viewport;

import com.labwork.texturesexample.rendering.viewport.common.ViewportConfigurable;

public class MainActivity extends AppCompatActivity {

private static final int MENU\_ITEM\_SCENE\_EARTH = 1;

private static final int MENU\_ITEM\_SCENE\_TORUS = 2;

private static final int MENU\_ITEM\_SCENE\_SKYBOX = 3;

private Scene earthScene;

private Scene torusScene;

private Scene skyboxScene;

private Shader opaqueShader;

private Shader skyboxShader;

@Override

protected final void onCreate(Bundle savedInstanceState) {

ViewportConfigurable viewport = new Viewport(this);

RendererProgrammable renderer = new ForwardRenderer(this::initializeAssets);

super.onCreate(savedInstanceState);

super.setContentView(viewport.getLayout());

Framework.getInstance().initialize(renderer, viewport);

}

private void initializeAssets() {

this.opaqueShader = new Shader(OpaqueRenderFeature.class, Standalone.SHADER\_OPAQUE\_VERT\_SOURCE, Standalone.SHADER\_OPAQUE\_FRAG\_SOURCE);

this.skyboxShader = new Shader(SkyboxRenderFeature.class, Standalone.SHADER\_SKYBOX\_VERT\_SOURCE, Standalone.SHADER\_SKYBOX\_FRAG\_SOURCE);

Framework.getInstance().getRenderer().registerRenderFeature(new SkyboxRenderFeature(this.skyboxShader));

Framework.getInstance().getRenderer().registerRenderFeature(new OpaqueRenderFeature(this.opaqueShader));

this.earthScene = this.initializeEarthScene();

this.torusScene = this.initializeTorusScene();

this.skyboxScene = this.initializeSkyboxScene();

}

private Scene initializeEarthScene() {

Scene scene = new Scene();

Material material = new Material(this.opaqueShader, new Color(255, 255, 255, 0), new Texture2D(this, R.drawable.earth, GLES32.GL\_CLAMP\_TO\_EDGE, GLES32.GL\_LINEAR), 0.3f, 0.7f, 0.0f);

Entity sphere = new Entity();

sphere.addComponent(new TransformComponent(sphere));

Mesh sphereMesh = new Mesh(this.generateEarthVertices(), this.generateEarthIndices(), GLES32.GL\_TRIANGLES);

sphere.addComponent(new OpaqueRenderingComponent(sphere, sphereMesh, material));

scene.addEntity(sphere);

Entity camera = new Entity();

camera.addComponent(new TransformComponent(camera));

camera.addComponent(new CameraPerspectiveComponent(camera, new Color(27, 27, 27, 255), 0.001f, 100.0f, 90.0f, 90.0f));

camera.addComponent(new NoClipControllerComponent(camera, new Button(this), new Button(this), new Button(this),

new Button(this), new Button(this), new Button(this), new Button(this), new Button(this)));

scene.addEntity(camera);

camera.getComponent(TransformComponent.class).getPosition().setY(1.5f);

camera.getComponent(TransformComponent.class).getPosition().setZ(-3.0f);

camera.getComponent(TransformComponent.class).getRotation().setX(15.0f);

return scene;

}

private Scene initializeTorusScene() {

Scene scene = new Scene();

Material torusMaterial = new Material(this.opaqueShader, new Color(255, 255, 255, 0), new Texture2D(this, R.drawable.torus, GLES32.GL\_CLAMP\_TO\_EDGE, GLES32.GL\_LINEAR), 0.3f, 0.7f, 0.0f);

Entity torus = new Entity();

torus.addComponent(new TransformComponent(torus));

Mesh torusMesh = new Mesh(this.generateTorusVertices(), this.generateTorusIndices(), GLES32.GL\_TRIANGLES);

torus.addComponent(new OpaqueRenderingComponent(torus, torusMesh, torusMaterial));

scene.addEntity(torus);

Material planeMaterial = new Material(this.opaqueShader, new Color(255, 255, 255, 0), new Texture2D(this, R.drawable.chess, GLES32.GL\_REPEAT, GLES32.GL\_LINEAR), 0.3f, 0.7f, 0.0f);

Entity plane = new Entity();

plane.addComponent(new TransformComponent(plane));

Mesh planeMesh = new Mesh(this.generatePlaneVertices(), this.generatePlaneIndices(), GLES32.GL\_TRIANGLES);

plane.addComponent(new OpaqueRenderingComponent(plane, planeMesh, planeMaterial));

scene.addEntity(plane);

plane.getComponent(TransformComponent.class).getPosition().setY(-0.5f);

Entity camera = new Entity();

camera.addComponent(new TransformComponent(camera));

camera.addComponent(new CameraPerspectiveComponent(camera, new Color(27, 27, 27, 255), 0.001f, 100.0f, 90.0f, 90.0f));

camera.addComponent(new NoClipControllerComponent(camera, new Button(this), new Button(this), new Button(this), new Button(this), new Button(this), new Button(this), new Button(this), new Button(this)));

scene.addEntity(camera);

camera.getComponent(TransformComponent.class).getPosition().setY(1.5f);

camera.getComponent(TransformComponent.class).getPosition().setZ(-3.0f);

camera.getComponent(TransformComponent.class).getRotation().setX(15.0f);

return scene;

}

private Scene initializeSkyboxScene() {

Scene scene = new Scene();

Material torusMaterial = new Material(this.opaqueShader, new Color(255, 255, 255, 0), new Texture2D(this, R.drawable.torus, GLES32.GL\_CLAMP\_TO\_EDGE, GLES32.GL\_LINEAR), 0.3f, 0.7f, 0.0f);

Entity torus = new Entity();

torus.addComponent(new TransformComponent(torus));

Mesh torusMesh = new Mesh(this.generateTorusVertices(), this.generateTorusIndices(), GLES32.GL\_TRIANGLES);

torus.addComponent(new OpaqueRenderingComponent(torus, torusMesh, torusMaterial));

scene.addEntity(torus);

Material planeMaterial = new Material(this.opaqueShader, new Color(255, 255, 255, 0), new Texture2D(this, R.drawable.chess, GLES32.GL\_REPEAT, GLES32.GL\_LINEAR), 0.3f, 0.7f, 0.0f);

Entity plane = new Entity();

plane.addComponent(new TransformComponent(plane));

Mesh planeMesh = new Mesh(this.generatePlaneVertices(), this.generatePlaneIndices(), GLES32.GL\_TRIANGLES);

plane.addComponent(new OpaqueRenderingComponent(plane, planeMesh, planeMaterial));

scene.addEntity(plane);

plane.getComponent(TransformComponent.class).getPosition().setY(-0.5f);

int[] skyboxTextures = {

R.drawable.skybox\_right,

R.drawable.skybox\_left,

R.drawable.skybox\_top,

R.drawable.skybox\_bottom,

R.drawable.skybox\_front,

R.drawable.skybox\_back

};

Texture3D skyboxTexture = new Texture3D(this, skyboxTextures, GLES32.GL\_CLAMP\_TO\_EDGE, GLES32.GL\_LINEAR);

Material skyboxMaterial = new Material(this.skyboxShader, new Color(255, 255, 255, 255), null, 0.0f, 0.0f, 0.0f);

Mesh skyboxMesh = new Mesh(generateSkyboxCubeVertices(), generateSkyboxCubeIndices(), GLES32.GL\_TRIANGLES);

Entity skybox = new Entity();

skybox.addComponent(new TransformComponent(skybox));

skybox.addComponent(new SkyboxRenderingComponent(skybox, skyboxMesh, skyboxMaterial, skyboxTexture));

scene.addEntity(skybox);

Entity camera = new Entity();

camera.addComponent(new TransformComponent(camera));

camera.addComponent(new CameraPerspectiveComponent(camera, new Color(27, 27, 27, 255), 0.001f, 100.0f, 90.0f, 90.0f));

camera.addComponent(new NoClipControllerComponent(camera, new Button(this), new Button(this), new Button(this), new Button(this), new Button(this), new Button(this), new Button(this), new Button(this)));

scene.addEntity(camera);

camera.getComponent(TransformComponent.class).getPosition().setY(1.5f);

camera.getComponent(TransformComponent.class).getPosition().setZ(-3.0f);

camera.getComponent(TransformComponent.class).getRotation().setX(15.0f);

return scene;

}

private float[] generateSkyboxCubeVertices() {

int index = 0;

float size = 50.0f;

float[] vertices = new float[24 \* 11];

vertices[index++] = -size; vertices[index++] = -size; vertices[index++] = size;

vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = -size; vertices[index++] = size;

vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = size; vertices[index++] = size;

vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = size; vertices[index++] = size;

vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = -size; vertices[index++] = -size;

vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = -1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = -size; vertices[index++] = -size;

vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = -1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = size; vertices[index++] = -size;

vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = -1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = size; vertices[index++] = -size;

vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = 0.0f; vertices[index++] = -1.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = -size; vertices[index++] = -size;

vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = -1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = -size; vertices[index++] = size;

vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = -1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = size; vertices[index++] = size;

vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = size; vertices[index++] = -size;

vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = -1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = -size; vertices[index++] = size;

vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = -size; vertices[index++] = -size;

vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = size; vertices[index++] = -size;

vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = 1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = size; vertices[index++] = size;

vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 1.0f; vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = size; vertices[index++] = size;

vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = size; vertices[index++] = size;

vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = size; vertices[index++] = -size;

vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = size; vertices[index++] = -size;

vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = -size; vertices[index++] = -size;

vertices[index++] = 0.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = -1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = -size; vertices[index++] = -size;

vertices[index++] = 1.0f; vertices[index++] = 0.0f;

vertices[index++] = 0.0f; vertices[index++] = -1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = size; vertices[index++] = -size; vertices[index++] = size;

vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = -1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

vertices[index++] = -size; vertices[index++] = -size; vertices[index++] = size;

vertices[index++] = 0.0f; vertices[index++] = 1.0f;

vertices[index++] = 0.0f; vertices[index++] = -1.0f; vertices[index++] = 0.0f;

vertices[index++] = 1.0f; vertices[index++] = 1.0f; vertices[index++] = 1.0f;

return vertices;

}

private int[] generateSkyboxCubeIndices() {

return new int[] {

0, 1, 2, 0, 2, 3, // Front

4, 5, 6, 4, 6, 7, // Back

8, 9, 10, 8, 10, 11, // Left

12, 13, 14, 12, 14, 15, // Right

16, 17, 18, 16, 18, 19, // Top

20, 21, 22, 20, 22, 23 // Bottom

};

}

private float[] generateEarthVertices() {

int latitudeBands = 32;

int longitudeBands = 64;

float radius = 1.0f;

int vertexCount = (latitudeBands + 1) \* (longitudeBands + 1);

float[] vertices = new float[vertexCount \* 11];

int index = 0;

for (int lat = 0; lat <= latitudeBands; lat++) {

float theta = lat \* (float)Math.PI / latitudeBands;

float sinTheta = (float)Math.sin(theta);

float cosTheta = (float)Math.cos(theta);

for (int lon = 0; lon <= longitudeBands; lon++) {

float phi = lon \* 2 \* (float)Math.PI / longitudeBands;

float sinPhi = (float)Math.sin(phi);

float cosPhi = (float)Math.cos(phi);

float x = cosPhi \* sinTheta;

float y = cosTheta;

float z = sinPhi \* sinTheta;

float u = 1.0f - ((float)lon / longitudeBands);

float v = (float)lat / latitudeBands;

vertices[index++] = x \* radius;

vertices[index++] = y \* radius;

vertices[index++] = z \* radius;

vertices[index++] = u;

vertices[index++] = v;

vertices[index++] = x;

vertices[index++] = y;

vertices[index++] = z;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

}

}

return vertices;

}

private int[] generateEarthIndices() {

int latitudeBands = 32;

int longitudeBands = 64;

int indexCount = latitudeBands \* longitudeBands \* 6;

int[] indices = new int[indexCount];

int index = 0;

for (int lat = 0; lat < latitudeBands; lat++) {

for (int lon = 0; lon < longitudeBands; lon++) {

int first = (lat \* (longitudeBands + 1)) + lon;

int second = first + longitudeBands + 1;

indices[index++] = first;

indices[index++] = second;

indices[index++] = first + 1;

indices[index++] = second;

indices[index++] = second + 1;

indices[index++] = first + 1;

}

}

return indices;

}

private float[] generateTorusVertices() {

int radialSegments = 32;

int tubularSegments = 64;

float radius = 1.5f;

float tubeRadius = 0.5f;

int vertexCount = (radialSegments + 1) \* (tubularSegments + 1);

float[] vertices = new float[vertexCount \* 11];

int index = 0;

for (int i = 0; i <= radialSegments; i++) {

float u = i / (float)radialSegments \* (float)Math.PI \* 2;

float cosU = (float)Math.cos(u);

float sinU = (float)Math.sin(u);

for (int j = 0; j <= tubularSegments; j++) {

float v = j / (float)tubularSegments \* (float)Math.PI \* 2;

float cosV = (float)Math.cos(v);

float sinV = (float)Math.sin(v);

float x = (radius + tubeRadius \* cosV) \* cosU;

float y = tubeRadius \* sinV;

float z = (radius + tubeRadius \* cosV) \* sinU;

float nx = cosV \* cosU;

float ny = sinV;

float nz = cosV \* sinU;

float texU = (float)i / radialSegments;

float texV = (float)j / tubularSegments;

vertices[index++] = x;

vertices[index++] = y;

vertices[index++] = z;

vertices[index++] = texU;

vertices[index++] = texV;

vertices[index++] = nx;

vertices[index++] = ny;

vertices[index++] = nz;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

}

}

return vertices;

}

private int[] generateTorusIndices() {

int radialSegments = 32;

int tubularSegments = 64;

int indexCount = radialSegments \* tubularSegments \* 6;

int[] indices = new int[indexCount];

int index = 0;

for (int i = 0; i < radialSegments; i++) {

for (int j = 0; j < tubularSegments; j++) {

int a = (tubularSegments + 1) \* i + j;

int b = (tubularSegments + 1) \* (i + 1) + j;

int c = (tubularSegments + 1) \* (i + 1) + j + 1;

int d = (tubularSegments + 1) \* i + j + 1;

indices[index++] = a;

indices[index++] = b;

indices[index++] = d;

indices[index++] = b;

indices[index++] = c;

indices[index++] = d;

}

}

return indices;

}

private float[] generatePlaneVertices() {

float size = 2.25f;

float repeatFactor = 1.5f;

int index = 0;

float[] vertices = new float[4 \* 11];

vertices[index++] = -size / 2;

vertices[index++] = 0.0f;

vertices[index++] = -size / 2;

vertices[index++] = 0.0f;

vertices[index++] = 0.0f;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = size / 2;

vertices[index++] = 0.0f;

vertices[index++] = -size / 2;

vertices[index++] = repeatFactor \* 2;

vertices[index++] = 0.0f;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = size / 2;

vertices[index++] = 0.0f;

vertices[index++] = size / 2;

vertices[index++] = repeatFactor \* 2;

vertices[index++] = repeatFactor \* 2;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = -size / 2;

vertices[index++] = 0.0f;

vertices[index++] = size / 2;

vertices[index++] = 0.0f;

vertices[index++] = repeatFactor \* 2;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 0.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

vertices[index++] = 1.0f;

return vertices;

}

private int[] generatePlaneIndices() {

int[] indices = new int[6];

indices[0] = 0; // Bottom-left

indices[1] = 1; // Bottom-right

indices[2] = 2; // Top-right

indices[3] = 0; // Bottom-left

indices[4] = 2; // Top-right

indices[5] = 3; // Top-left

return indices;

}

@Override

public boolean onCreateOptionsMenu(Menu menu) {

menu.add(0, MENU\_ITEM\_SCENE\_EARTH, 0, "Earth");

menu.add(0, MENU\_ITEM\_SCENE\_TORUS, 0, "Torus");

menu.add(0, MENU\_ITEM\_SCENE\_SKYBOX, 0, "Skybox");

return true;

}

@Override

public boolean onOptionsItemSelected(MenuItem item) {

super.setTitle(item.getTitle());

switch (item.getItemId()) {

case MENU\_ITEM\_SCENE\_EARTH:

Framework.getInstance().loadScene(this.earthScene);

return true;

case MENU\_ITEM\_SCENE\_TORUS:

Framework.getInstance().loadScene(this.torusScene);

return true;

case MENU\_ITEM\_SCENE\_SKYBOX:

Framework.getInstance().loadScene(this.skyboxScene);

return true;

default:

return super.onOptionsItemSelected(item);

}

}

}

# ВИСНОВКИ

У процесі виконання лабораторної роботи №5 створено застосунок Lab5\_GLES із трьома режимами роботи: рендеринг текстурованого тору разом із чотирикутником шахової дошки, кулі з текстурою планети на основі космічних знімків та куба Skybox із тором усередині для створення ефекту навколишнього середовища. У кожному режимі реалізовано інтерактивне керування сценою – повороти по горизонталі й вертикалі та зміну відстані до об’єктів, що забезпечило гнучкість огляду. Робота охопила використання текстурних координат, циклічного повторення зображень та оптимізацію рендерингу.

Було опрацьовано ключові аспекти текстурування в OpenGL ES: завантаження текстур, створення атласів, програмування шейдерів для обробки вершин і фрагментів, а також налагодження програми на емуляторі та фізичному пристрої Android. Виконання завдань дозволило поглибити розуміння принципів роботи з текстурами та здобути практичні навички програмування реалістичної графіки тривимірних об’єктів, досягнувши поставленої мети лабораторної роботи.