Programowanie 3W grafiki w OpenGL. Import modeli z Blendera w OpenGL

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Najnowsza wersja tego dokumentu dostępna jest pod adresem
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Wprowadzenie

Przykład modelu zaimportowanego

- Blender $\longrightarrow$ Wavefront .obj $\longrightarrow$ OpenGL

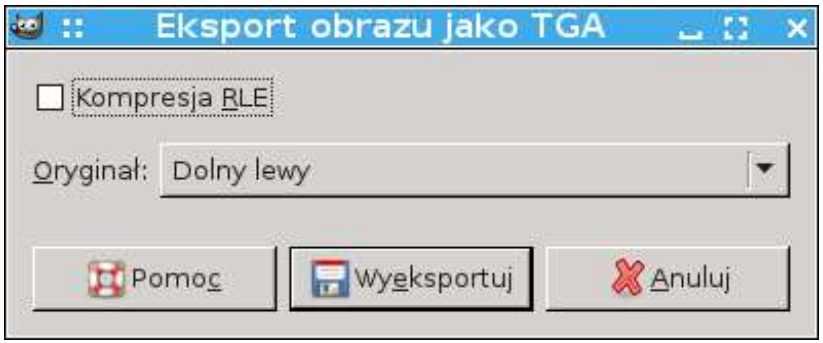
Eksport modeli z Blendera

- rozłożenie modelu na płaszczyźnie (UV mapping)
- Wypiekanie tekstury
- eksport w obj

- zazancz krawędzie-szwy, `Mark Seam`
- nowy obrazek w edutorze UV, bez przezroczystości
- zazancz wszystkie krawędzie, `Unwrap` (być może dwa razy)

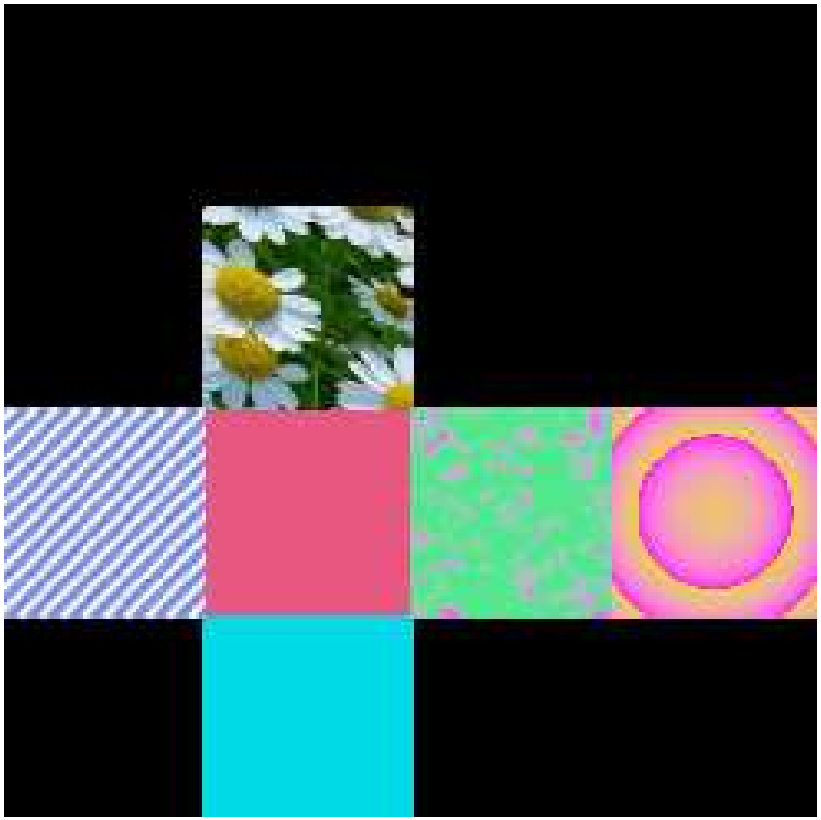
Wypiekanie tekstury

- zakładka `Render`
  - opcja `Textures`
  - przycisk `Bake`
- zapisać teksturę jako png
- skonwertować do tga



- wypróbować format tga w Blenderze

Przykład tekstury



Eksport w obj

- menu `File`, `Export`, `Wavefront (.obj)`
- opcje `Include Normals`, `Triangulate Faces`, `Selection Only`

Format Wavefront .obj

- Wavefront Technologies
- format jest legalny, przyjęty przez wszystkich wytwórców 3W aplikucji
- dwa pliki

- `*.obj` — informacja o wierzchołkach
- `*.mtl` — informacja o materiałach

Przykładowy plik .mtl


```
# Blender MTL File: 'kostka.blend'
# Material Count: 3
newmtl Material.001_untitled
Ns 96.078431
Ka 0.000000 0.000000 0.000000
Kd 0.640000 0.075960 0.174290
Ks 0.500000 0.500000 0.500000
Ni 1.000000
d 1.000000
illum 2
map_Kd tekstura.png
 ..............................
```

```
 ..............................
newmtl Material.002_untitled
Ns 96.078431
Ka 0.000000 0.000000 0.000000
Kd 0.640000 0.640000 0.640000
Ks 0.000000 0.000000 0.000000
Ni 1.000000
d 1.000000
illum 1
map_Kd tekstura.png
 ..............................
```

Trzeci materiał


```
.....................................
newmtl Material_untitled
Ns 96.078431
Ka 0.000000 0.000000 0.000000
Kd 0.640000 0.640000 0.640000
Ks 0.500000 0.500000 0.500000
Ni 1.000000
d 1.000000
illum 2
map_Kd tekstura.png
```

Przykładowy plik .obj


```
# Blender v2.63 (sub 0) OBJ File: 'kostka.blend'
# www.blender.org
mtllib kostka.mtl
o Cube
v 1.000000 -1.000000 -1.000000
v 1.000000 -1.000000 1.000000
v -1.000000 -1.000000 1.000000
v -1.000000 -1.000000 -1.000000
v 1.000000 1.000000 -0.999999
v 0.999999 1.000000 1.000001
v -1.000000 1.000000 1.000000
v -1.000000 1.000000 -1.000000
 ..............................
```

Współrzędne tekstury


```
.....................................
vt 0.249999 0.250000
vt 0.250000 0.500000
vt 0.000000 0.500000
vt 0.000000 0.250000
vt 0.499999 0.250000
vt 0.749999 0.250000
vt 0.750000 0.500000
vt 0.499999 0.500000
vt 1.000000 0.500000
vt 1.000000 0.249999
vt 0.249999 0.000000
vt 0.499999 0.000000
vt 0.499999 0.749999
vt 0.249999 0.749999

.....................................
```

```
.....................................
vn 0.000000 -1.000000 0.000000
vn 0.000000 1.000000 0.000000
vn -1.000000 -0.000000 -0.000000
vn 0.000000 0.000000 -1.000000
vn 1.000000 0.000000 0.000000
vn -0.000000 -0.000000 1.000000

.....................................
```

```
usemtl Material_untitled
s off
f 1/1/1 2/2/1 3/3/1
f 1/1/1 3/3/1 4/4/1
f 5/5/2 8/6/2 7/7/2
f 5/5/2 7/7/2 6/8/2
f 3/9/3 7/7/3 8/6/3
f 3/9/3 8/6/3 4/10/3
f 5/5/4 1/1/4 4/11/4
f 5/5/4 4/11/4 8/12/4
```

Druga i trzecia grupa wierzchołków

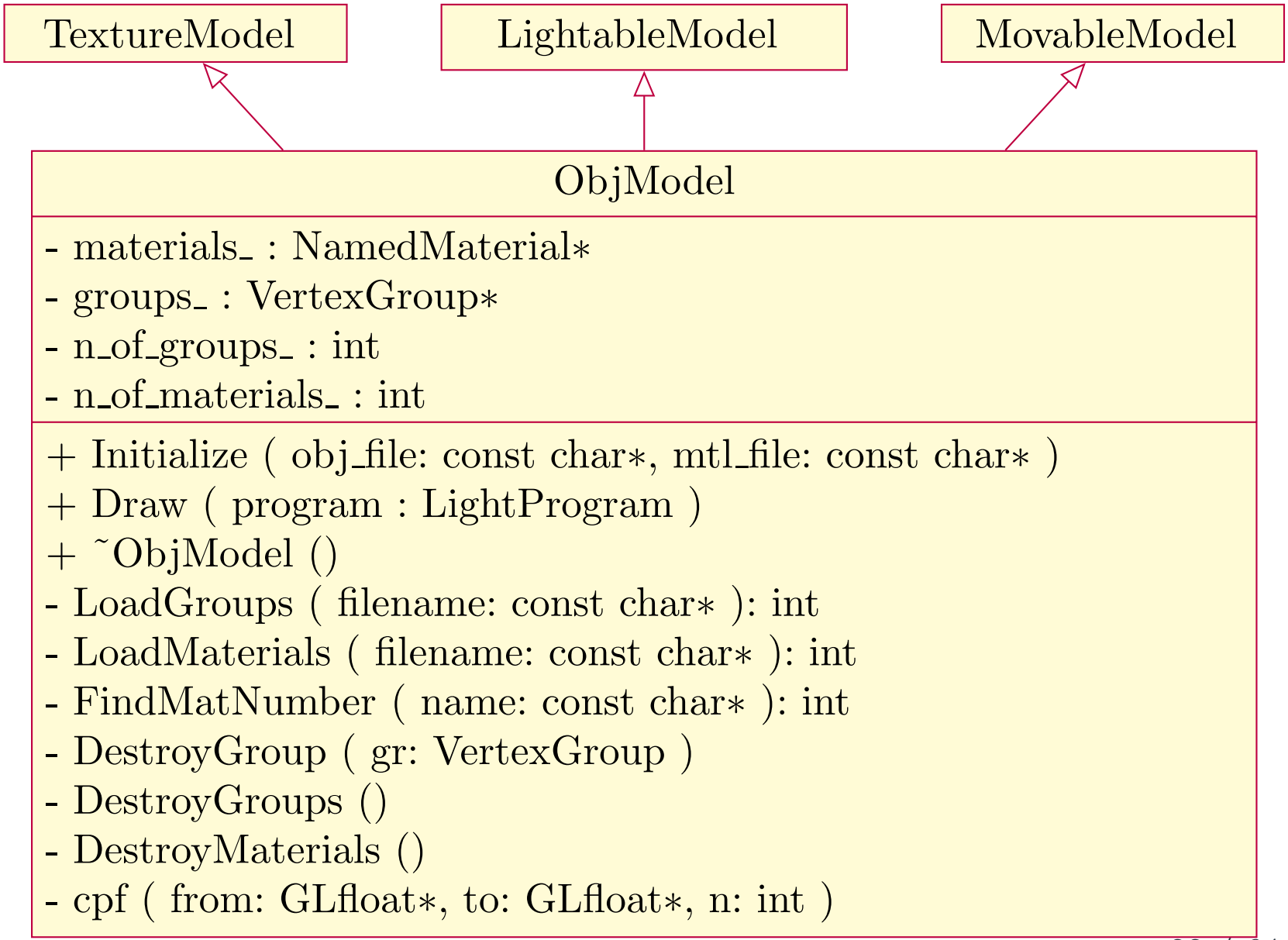

```
 ..............................
usemtl Material.001_untitled
f 1/1/5 5/5/5 6/8/5
f 1/1/5 6/8/5 2/2/5
usemtl Material.002_untitled
f 2/2/6 6/8/6 7/13/6
f 2/2/6 7/13/6 3/14/6
 ..............................
```

Importujemy właściwości

- `newmtl` —nazwę materiału
- `Ka` — trójwymiarowy współczynnik odbicia światła naturalnego (ambient), dodajemy czwartą współrzędną $\alpha = 1$
- `Kd` — trójwymiarowy współczynnik odbicia rozproszonego (diffuse), dodajemy czwartą współrzędną $\alpha = 1$
- `Ks` — trójwymiarowy współczynnik odbicia zwierciadlanego , dodajemy czwartą współrzędną $\alpha = 1$
- `Ns` — wskaźnik odbicia zwierciadlanego

Import

```
typedef struct NamedMaterial{
  char name_[30];
  Material m;
} NamedMaterial;

typedef struct VertexGroup{
  GLuint vao;
  GLuint vertices;
  int mat_number;
  int n_of_vertices;
} VertexGroup;

typedef GLfloat Vec2[2];
typedef GLfloat Vec3[3];
```



Klasa ObjModel


```
class ObjModel{
public:
    void Initialize(const char *obj_file,
      const char *mtl_file);
    void Draw(const PointLightProgram &);
    ~ObjModel();
```

Dane prywatne


```
private:
    NamedMaterial * materials_;
    VertexGroup * groups_;
    int n_of_groups_;
    int n_of_materials_;

    int LoadGroups(const char * filename);
    int LoadMaterials(const char* filename);
    int FindMatNumber(const char* MatName);
    void DestroyGroup(VertexGroup gr);
    void DestroyGroups();
    void DestroyMaterials(void);
```

```
void ObjModel::Initialize(
                const char *obj_file,
                const char *mtl_file )
{
    n_of_materials_=LoadMaterials(mtl_file);
    n_of_groups_=LoadGroups(obj_file);
}
```

```
int ObjModel::LoadMaterials(const char* filename){
  int n_of=-1;
  int maxMat=2;
  int d_mat=2;
  char mode[10];
  NamedMaterial * new_materials;

  ifstream file (filename, ios::in|ios::binary);

  if (file.is_open()) {
    materials_ = (NamedMaterial*)
                 malloc(maxMat*sizeof(NamedMaterial));

   while(file>>mode){
```

Nowy materiał. Alokacja nowej pamięci


```
if(strcmp("newmtl",(const char*)mode)==0){
    n_of++;
    if(n_of>=maxMat){
        maxMat+=d_mat;
        new_materials
            =(NamedMaterial*)realloc(
            materials_, maxMat*sizeof(NamedMaterial) );
        if(NULL!=new_materials) materials_=new_materials;
        else {
        cerr<< "ERROR:\n";
        file.close();
        exit(EXIT_FAILURE);
        }
    }
```

Nowy materiał. Nazwa i światło emitowane


```
    file>>materials_[n_of].name_;
    materials_[n_of].m.emission[0]=0.0f;
    materials_[n_of].m.emission[1]=0.0f;
    materials_[n_of].m.emission[2]=0.0f;
    materials_[n_of].m.emission[3]=1.0f;
}
```

Odbicie światła rozproszonego


```
else if(strcmp("Kd",(const char*)mode)==0){
    // diffuse
    file >> materials_[n_of].m.diffuse[0]
         >> materials_[n_of].m.diffuse[1]
         >> materials_[n_of].m.diffuse[2];
    materials_[n_of].m.diffuse[3]=1.0f;
}
```

Odbicie światła zwierciadlanego


```
else if(strcmp("Ks",(const char*)mode)==0){
    // specular
    file >> materials_[n_of].m.specular[0]
         >> materials_[n_of].m.specular[1]
         >> materials_[n_of].m.specular[2];
    materials_[n_of].m.specular[3]=1.0f;
}
```

Wskaźnik odbicia zwierciadlanego


```
else if(strcmp("Ns",(const char*)mode)==0){
    // shininess
    file>> materials_[n_of].m.shininess;
}
```

```
else if(strcmp("Ka",(const char*)mode)==0){
    // ambient
    file >> materials_[n_of].m.ambient[0]
         >> materials_[n_of].m.ambient[1]
         >> materials_[n_of].m.ambient[2];
    materials_[n_of].m.ambient[3]=1.0f;
}
```

```
            else file.ignore(1024,'\n');
          }
          file.close();
        }
        else{
            cerr<<"ERROR: " << filename<<endl;
            exit(EXIT_FAILURE);
         }
        return n_of+1;
    }
```

LoadGroups: zmienne pomocnicze


```
int ObjModel::LoadGroups(const char * filename){
  int n_of=-1; // Groups
  int max=2;
  int delta=2;
  int mat_number=-1;
  int n_of_vert=-1; //vertices
  int max_vert=2;
  int d_vert=2;
  int n_of_vert_in_gr=-1; // vertices in group
  int max_v_in_g=6;
  int d_v_in_g=6; // >=3
  int n_of_tex=-1; // Texture
  int max_tex=2;
  int d_tex=2;
  int n_of_norm=-1; // normals
  int max_norm=2;
  int d_norm=2;
```

Jeszcze zmienne pomocnicze


```
VertexGroup * new_groups;
Vec3 * vertices;
NormalTextureVertex * vertices_in_gr;
Vec2 * tex_coords;
Vec3 * normals;
Vec3 * new_vertices;
NormalTextureVertex * new_vertices_in_gr;
Vec2 * new_tex_coords;
Vec3 * new_normals;

int v,t,n; //vertex data
```

Otwieramy plik...


```
ifstream file (filename, ios::in|ios::binary);

if (file.is_open()) {
   groups_ = (VertexGroup*)
      malloc(max*sizeof(VertexGroup));
   vertices = (Vec3*) malloc(max_vert*sizeof(Vec3));
   vertices_in_gr = (NormalTextureVertex*)
      malloc(max_v_in_g*sizeof(NormalTextureVertex));
   tex_coords = (Vec2*) malloc(max_tex*sizeof(Vec2));
   normals = (Vec3*) malloc(max_norm*sizeof(Vec3));

   while (file>>mode) {
```

Nowy wierzchołek


```
if(strcmp("v",(const char*)mode)==0){
    //Vertex
    n_of_vert++;
    if(n_of_vert>=max_vert){
        max_vert+=d_vert;
        new_vertices = (Vec3*)
            realloc(vertices,max_vert*sizeof(Vec3));
        if(NULL!=new_vertices) vertices=new_vertices;
        else {
            cerr<< "ERROR: ...\n";
            exit(EXIT_FAILURE);
        }
    }
    file >> vertices[n_of_vert][0]
         >> vertices[n_of_vert][1]
         >> vertices[n_of_vert][2];
}
```

Nowy wektor normalny


```
else if(strcmp("vn",(const char*)mode)==0){
    //Normal
    n_of_norm++;
    if(n_of_norm>=max_norm){
        max_norm+=d_norm;
        new_normals =  (Vec3*)
          realloc(normals,max_norm*sizeof(Vec3));
        if(NULL!=new_normals) normals=new_normals;
        else {
            cerr<< "ERROR: ...";
            exit(EXIT_FAILURE);
        }
    }
    file >> normals[n_of_norm][0]
         >> normals[n_of_norm][1]
         >> normals[n_of_norm][2];
}
```

Nowa para współrzędnych teksturowych


```
else if(strcmp("vt",(const char*)mode)==0){
    //Texture
    n_of_tex++;
    if(n_of_tex>=max_tex){
        max_tex+=d_tex;
        new_tex_coords =  (Vec2*)
          realloc(tex_coords,max_tex*sizeof(Vec2));
        if (NULL!=new_tex_coords)
                              tex_coords=new_tex_coords;
        else {
            cerr<< "ERROR: ...\n";
            exit(EXIT_FAILURE);
        }
    }
    file >> tex_coords[n_of_tex][0]
         >> tex_coords[n_of_tex][1];
}
```

Ściana. Realokacja pamięci


```
else if(strcmp("f",(const char*)mode)==0){
    //Face
    if(n_of_vert_in_gr+3>=max_v_in_g){
        max_v_in_g+=d_v_in_g;
        new_vertices_in_gr = (NormalTextureVertex*)
          realloc(vertices_in_gr,
              max_v_in_g*sizeof(NormalTextureVertex));
        if(NULL!=new_vertices_in_gr)
                  vertices_in_gr=new_vertices_in_gr;
        else {
            cerr << "ERROR: ...\n";
            exit(EXIT_FAILURE);
        }
    }
```

```
    for(i=0;i<3;i++){
        // three vertices
        file >> v >> g >> t>> g >>n;
        n_of_vert_in_gr++;
        cpf(vertices[v-1],
            vertices_in_gr[n_of_vert_in_gr].position, 4);
        cpf(tex_coords[t-1],
            vertices_in_gr[n_of_vert_in_gr].texture, 2);
        cpf(normals[n-1],
             vertices_in_gr[n_of_vert_in_gr].normal, 3);
    }
}
```

- `void cpf(GLfloat* from, GLfloat* to, int n)` — pomocnicza funkcja do kopiowania danych z uzupełnieniem

```
void ObjModel::cpf(GLfloat* from,
    GLfloat* to, int n){
        if(n==4){
            to[3]=1.0f;
            n--;
        }
        while(n-->0){
            to[n]=from[n];
        }
        return;
}
```

- `void cpf(GLfloat* from, GLfloat* to, int n)` — pomocnicza funkcja do kopiowania danych z uzupełnieniem

Nowa grupa wierzchołków.

- Jeżeli grupa już została wczytana, jej dane wysyłamy na GPU
  - VAO

```
else if(strcmp("usemtl",(const char*)mode)==0){
//New group
if(n_of>=0){

    //send current group to GPU
    glGenVertexArrays(1, &groups_[n_of].vao);
    glBindVertexArray(groups_[n_of].vao);
```

Wysyłanie poprzedniej grupy na GPU. VBO


```
glGenBuffers(1, &groups_[n_of].vertices);
glBindBuffer(GL_ARRAY_BUFFER,
   groups_[n_of].vertices);
glBufferData(GL_ARRAY_BUFFER,
   (n_of_vert_in_gr+1)*sizeof(NormalTextureVertex),
   vertices_in_gr, GL_STATIC_DRAW);
```

Argumenty dla shadera


```
glVertexAttribPointer(0, 4, GL_FLOAT, GL_FALSE,
   sizeof(vertices_in_gr[0]), (GLvoid*)0);
glVertexAttribPointer(2, 2, GL_FLOAT, GL_FALSE,
   sizeof(vertices_in_gr[0]),
   (GLvoid*)sizeof(vertices_in_gr[0].position));
glVertexAttribPointer(3, 3, GL_FLOAT, GL_FALSE,
   sizeof(vertices_in_gr[0]),
   (GLvoid*)(sizeof(vertices_in_gr[0].position)
      + sizeof(vertices_in_gr[0].texture)));
glEnableVertexAttribArray(0);
glEnableVertexAttribArray(2);
glEnableVertexAttribArray(3);

glBindVertexArray(0);

groups_[n_of].n_of_vertices=n_of_vert_in_gr+1;
```

Ilość grup, realokacja


```
} //
n_of++;
if(n_of>=max){
    max+=delta;
    new_groups= (VertexGroup*)
        realloc(groups_,max*sizeof(VertexGroup));
    if(NULL!=new_groups) groups_=new_groups;
    else {
        cerr<< "ERROR: ...\n";
    exit(EXIT_FAILURE);
    }
}
```

```
file >> mat_name;
mat_number=FindMatNumber(mat_name);
if(mat_number<0){
    cerr<< "ERROR: Could not find material\n";
    exit(EXIT_FAILURE);
}
groups_[n_of].mat_number=mat_number;
n_of_vert_in_gr=-1;
```

```
}
else file.ignore(1024,'\n') ;

}// While
file.close();
if(n_of>=0){
    //send current group to GPU
     }

free(vertices);
free(vertices_in_gr);
free(tex_coords);
free(normals);
file.close();
```

Destruktor


```
ObjModel::~ObjModel(){
    DestroyGroups();
    DestroyMaterials();
}
```

```
void ObjModel::DestroyGroups(void){
    glDisableVertexAttribArray(1);
    glDisableVertexAttribArray(0);
    glBindBuffer(GL_ARRAY_BUFFER, 0);
    glBindBuffer(GL_ELEMENT_ARRAY_BUFFER, 0);
  int i;
  for (i=0;i< n_of_groups_; i++){
    DestroyGroup(groups_[i]);
  }
  free(groups_);
  n_of_groups_=0;
}
```

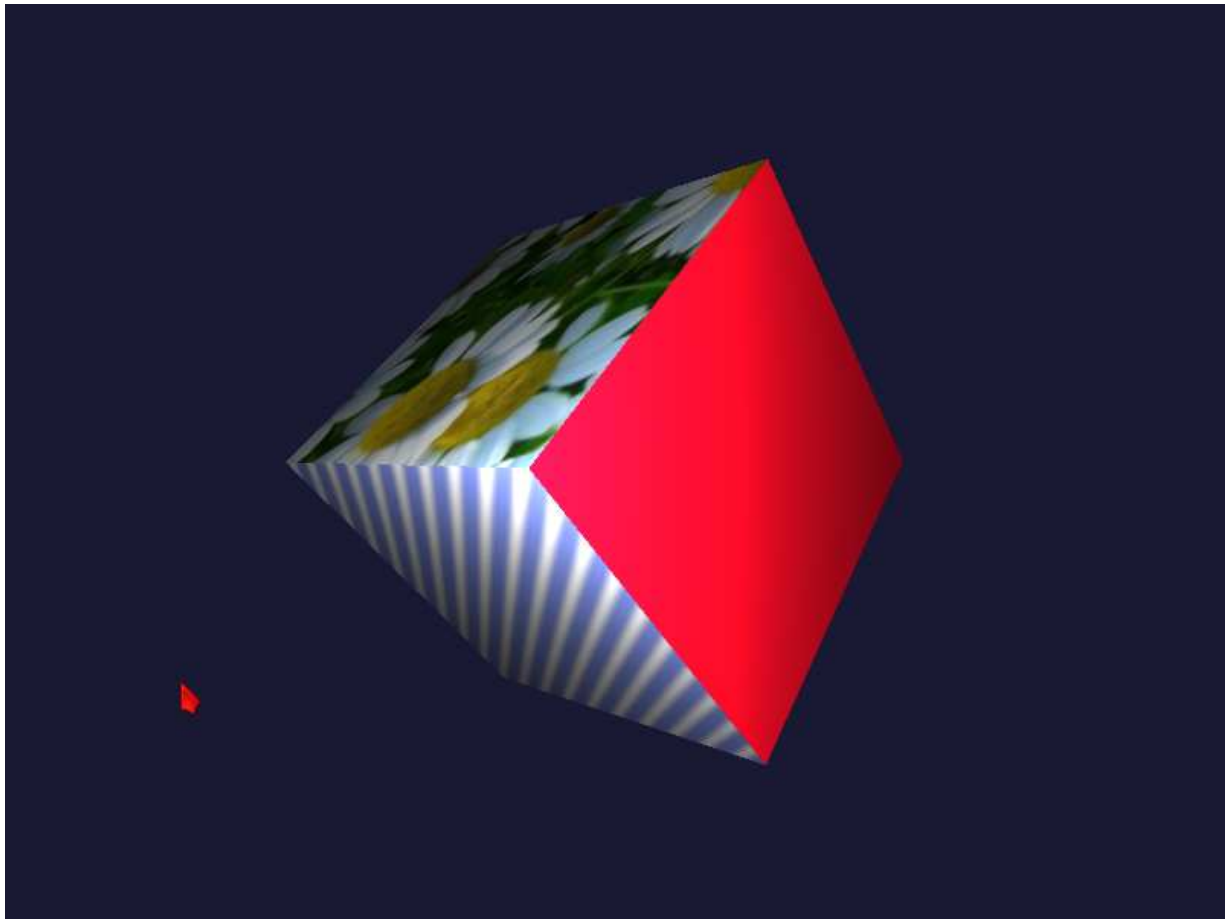
```
void ObjModel::DestroyGroup(VertexGroup gr){
    glDeleteBuffers(1, &gr.vao);
    glDeleteBuffers(1, &gr.vertices);
}
```

```
void ObjModel::DestroyMaterials(void)
{
  free(materials_);
  n_of_materials_=0;
}
```

```
void ObjModel::Draw(const LightProgram &prog){
  model_matrix_.SetUnitMatrix();
  model_matrix_.RotateAboutX(45);
  model_matrix_.RotateAboutY(-45);

  normal_matrix_.SetUnitMatrix();
  normal_matrix_.RotateAboutY(45);
  normal_matrix_.RotateAboutX(-45);

  glUseProgram(prog);
  prog.SetModelMatrix(model_matrix_);
  prog.SetNormalMatrix(normal_matrix_);
```

```
    glEnable(GL_CULL_FACE);
    glCullFace(GL_BACK);
    glFrontFace(GL_CCW);

    glActiveTexture(texture_unit_);
    glBindTexture(GL_TEXTURE_2D, texture_);

    for (int i=0; i<n_of_groups_; i++){
        glBindVertexArray(groups_[i].vao);
        prog.SetMaterial(
           materials_[groups_[i].mat_number].m);
        glDrawArrays(GL_TRIANGLES, 0,
           groups_[i].n_of_vertices);
        glBindVertexArray(0);
   }
    glDisable(GL_CULL_FACE);
    glUseProgram(0);
}
```

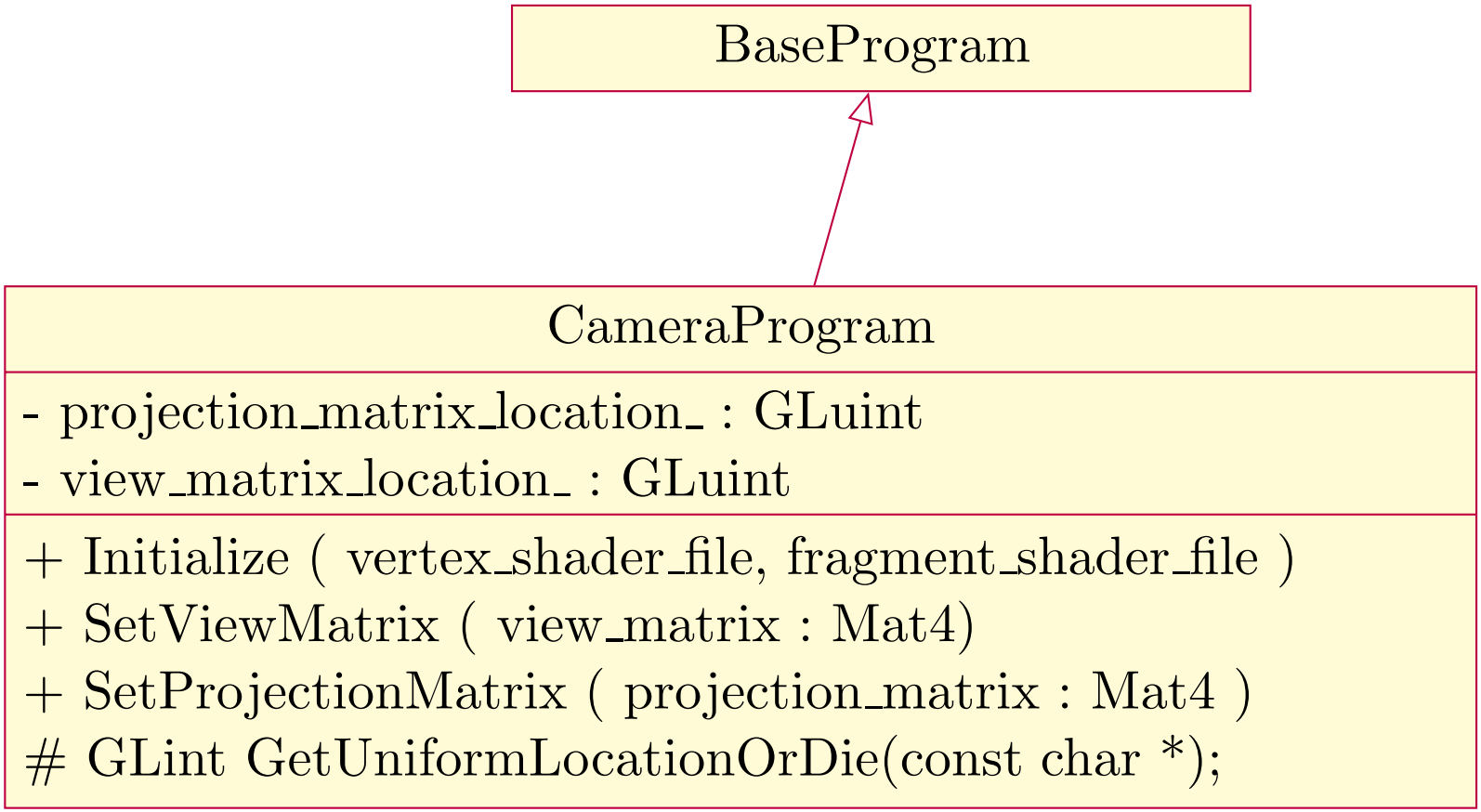
Implementacja

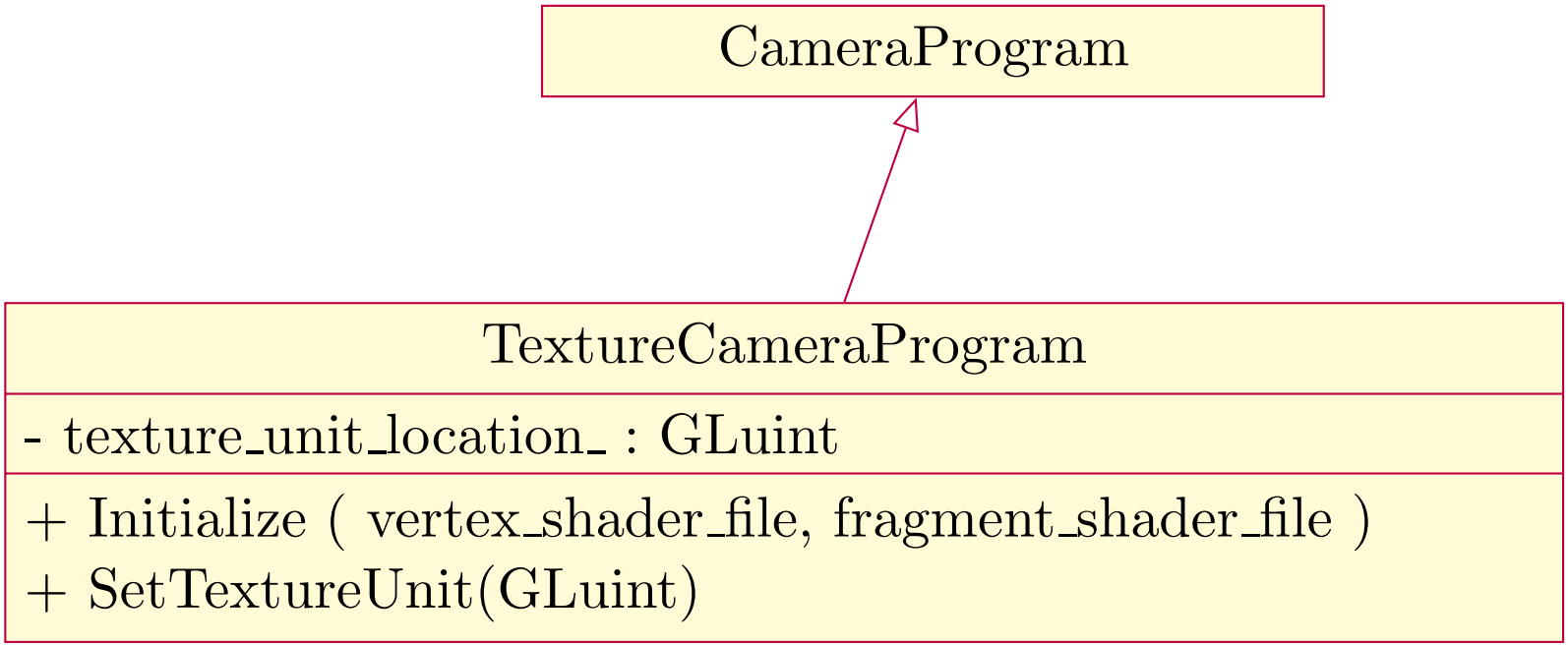


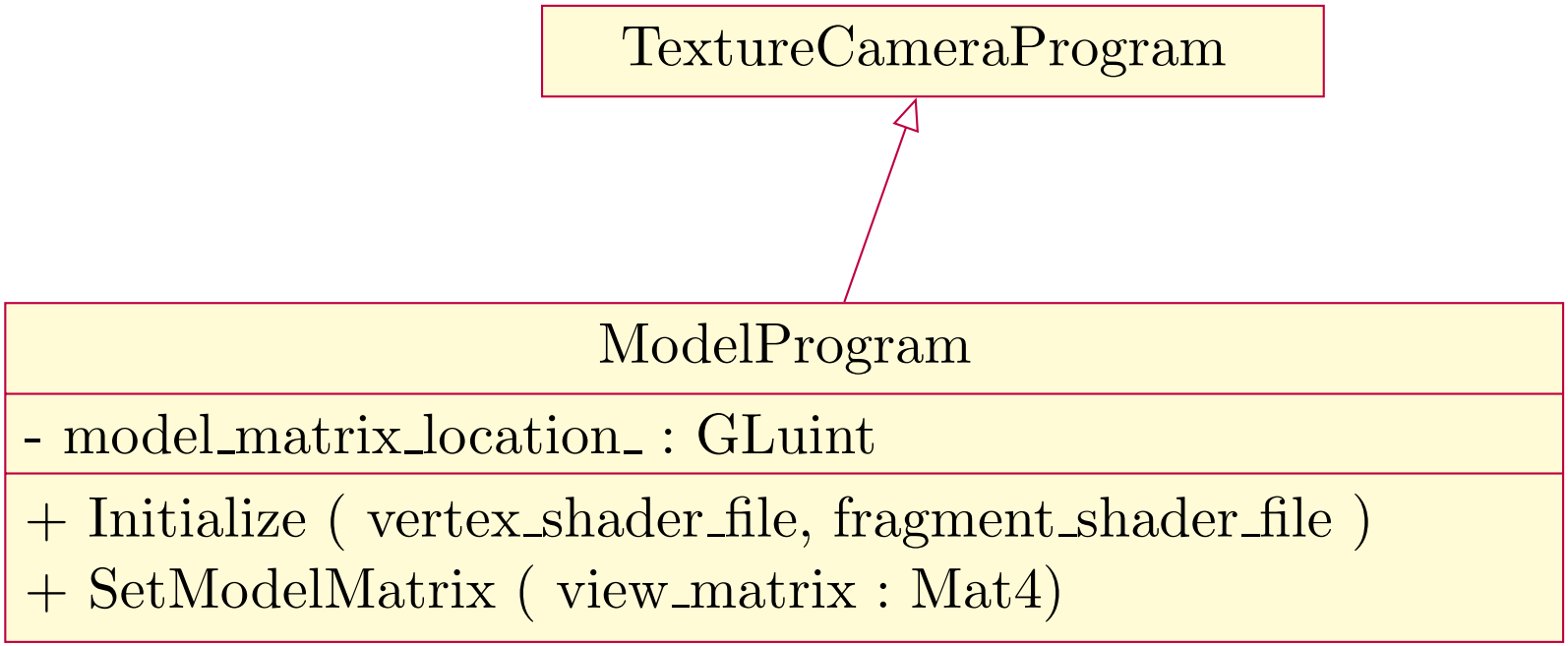
Hierarhia programów

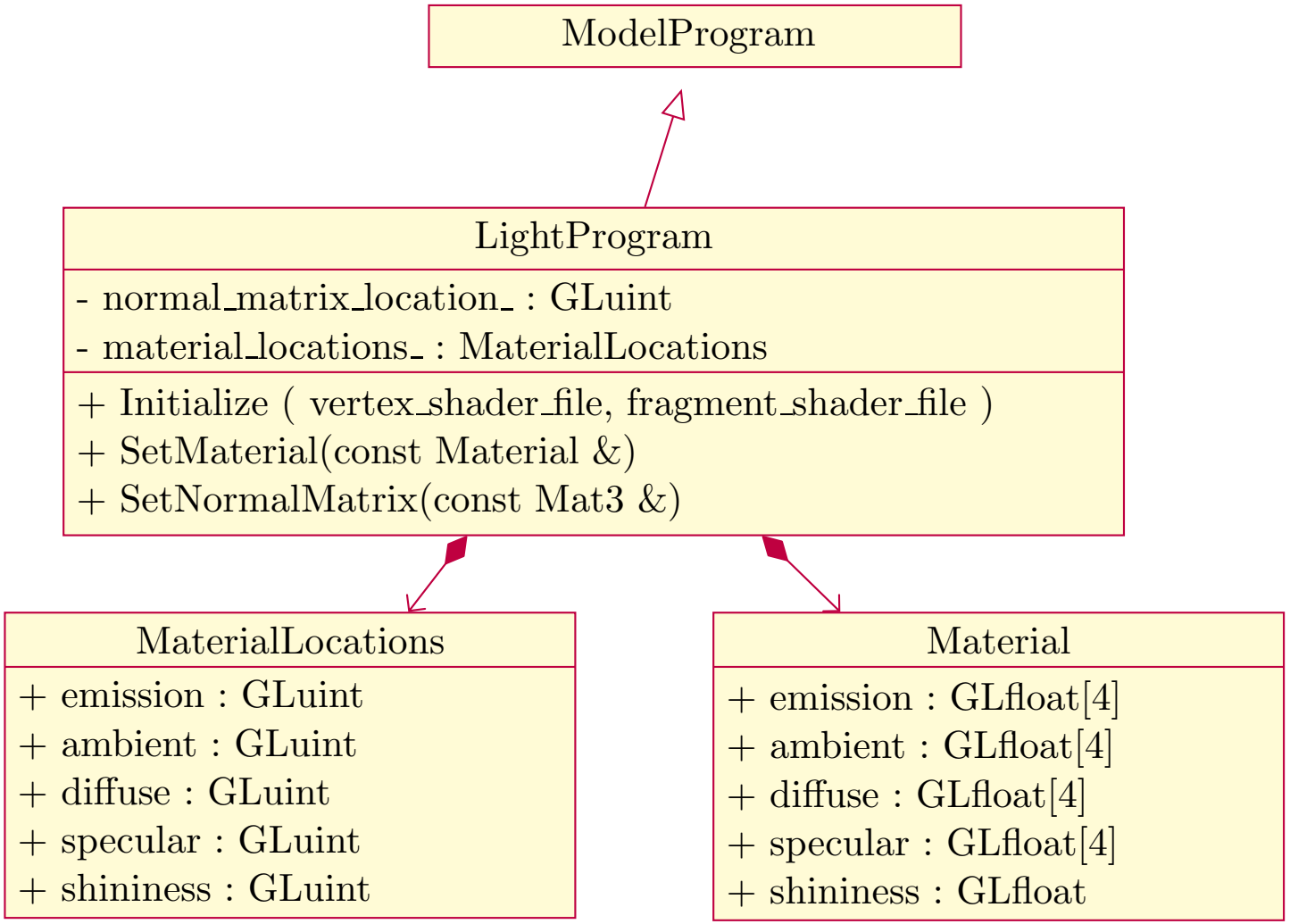
Program podstawowy

BaseProgram
program_ : GLuint - vertex_shader_ : GLuint - fragment_shader_ : GLuint
+ operator GLuint() const + ~BaseProgram () + Initialize (vertex_shader_file, fragment_shader_file) - LoadAndCompileShaderOrDie (source_file, type) - LinkProgramOrDie (vertex_shader, fragment_shader)

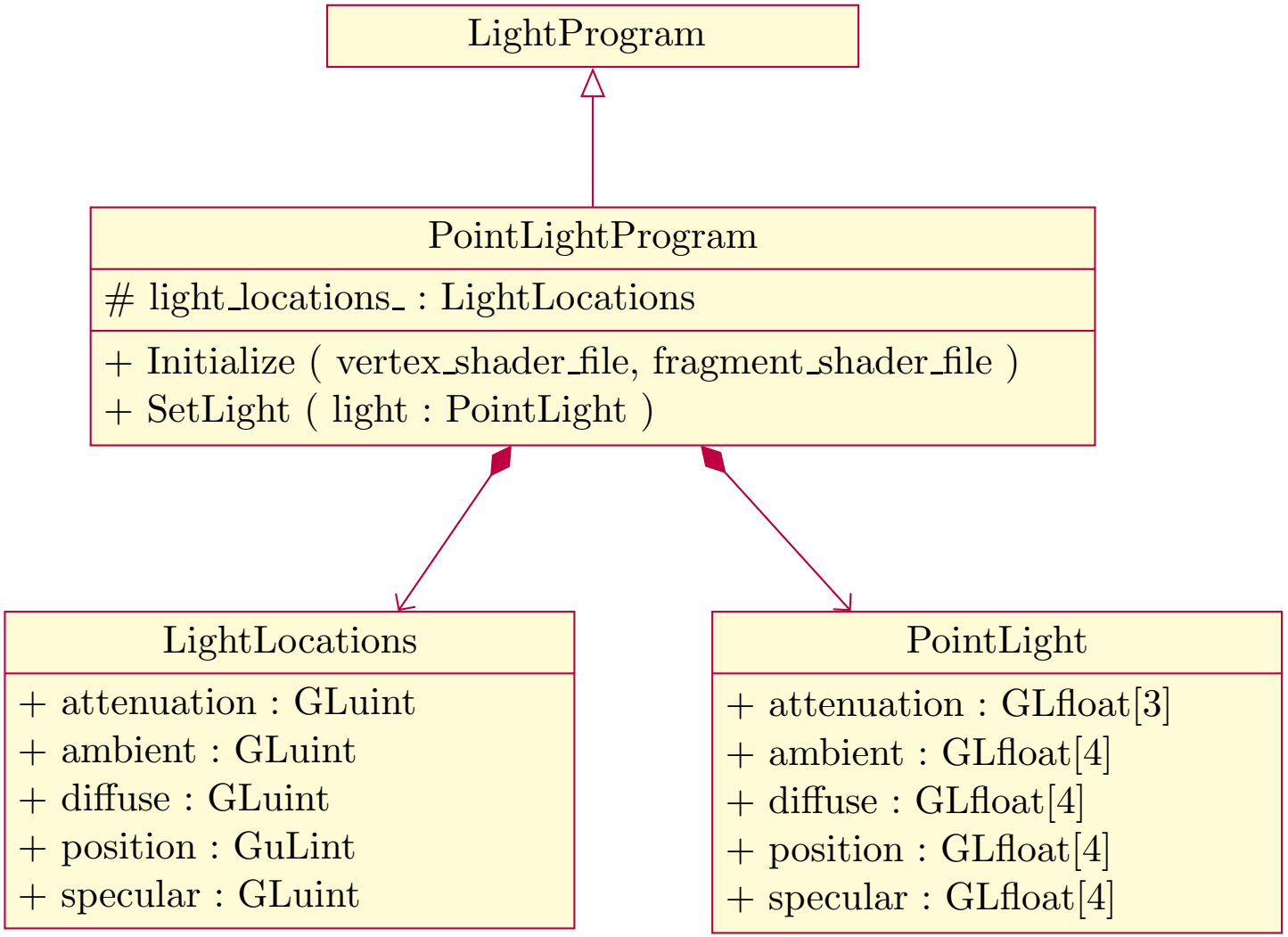








Program ze światłem punktowym



```
void PointLightProgram::Initialize(
        const char *vertex_shader_file,
        const char *fragment_shader_file){
    LightProgram::Initialize(vertex_shader_file,
        fragment_shader_file);
    light_locations_.ambient
      = GetUniformLocationOrDie("light.ambient");
    light_locations_.attenuation
      = GetUniformLocationOrDie("light.attenuation");
    light_locations_.diffuse
      = GetUniformLocationOrDie("light.diffuse");
    light_locations_.position
      = GetUniformLocationOrDie("light.position");
    light_locations_.specular
    = GetUniformLocationOrDie("light.specular");
}
```