Fillwave OpenGL 3.3+ (OpenGL ES 3.0+) graphics engine for C++

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Abstract

Before you start please ensure your graphics card driver supports at least OpenGL 3.3 and GLSL 330 or OpenGL ES 3.0 and GLSL 300 ES. Also, your c++ compiler must support c++11 standard (Ex. g++>4.7 or clang++>3.3). PC Context examples provided are using GLFW3. Android context samples use are using EGL (Java and native). Of course you can use any stub you like (Ex. freeglut, qt or other).

Contents

1 Introduction

1.1 Features

Graphics engine which you are about to use provides extremely, easy, portable, and uses C++11 modern API. It has all the essential functionalities that are needed to create a graphics layer for your application:

- Physics buffers for each model.
- Skybox and terrain generation.
- Renderable textures support.
- Spot and directional light support (Point lights will be available soon).
- Ortographic and Perspective projections.
- Easy to use callbacks mechanism.
- Flexible and easy event system.
- Lots of examples and Doxygen documentation.

Probably you will ask how is Fillwave better than other, more extended engines out there. The answer generally depends on what is your target. With this engine you can easily build a graphics layer to any game without installing any large IDE or lots of libraries. Fillwave provides an abstraction layer to OpenGL API introducing minimum overhead. It does not rely on the OpenGL context you have, so it can be used with GLFW, Freeglut or even with QT as weel. The android example (Using **native app glue** and EGL directly) is also available.

1.2 Getting started

The basic application skeleton looks like:

```
#include <fillwave/Fillwave.h>

using namespace fillwave;

int main(int argc, char* argv[]) {
  /* Create OpenGL context */
  Engine* engine = new Engine(argc, argv);
  /* Create scene */
  /* enter rendering loop */
  delete engine;
  exit(EXIT_SUCCESS);
}
```

1.3 Context creation

During the context initialization stage One must provide Fillwave engine a window (surface to draw on) and use **insert** functions in your context input handlers.

```
void insertResizeScreen(actions::KeyboardEvent& e);
void insertInputKey(actions::KeyboardEvent& e);
void insertInputMouseButton(actions::MouseButtonEvent& e);
void insertInputScroll(actions::ScrollEvent & e);
void insertInputCharacter(actions::CharacterEvent& e);
void insertInputCharacterMods(actions::CharacterModsEvent& e);
void insertInputCursorEnter(actions::CursorEnterEvent& e);
void insertInputCursorPosition(actions::CursorPositionEvent& e);
void insertInputTouchScreen(actions::TouchEvent& e);
```

Every time when there is an event incoming to you context, (Does not matter if you are using glfw, freegut, QT or other library) and you want Fillwave to handle it you should **insert** a proper event into the engine. Above there is an example using GLFW. The **keyboardCallback** function was previously registered as keyboard callback in GLFW.

```

void ContextGLFW1::keyboardCallback(GLFWwindow* window,
                                    int key,
```

```
                                int scancode,
                                int action,
                                int mods) {
  /* Create an event data and fill it */
  fillwave::actions::KeyboardEventData data;
  data.action = action;
  data.key = key;
  data.mode = mods;
  data.scanCode = scancode;

  /* Create an event */
  fillwave::actions::KeyboardEvent event(data);

  /* insert an event */
  mGraphicsEngine->insertInputKey(event);
}
```

1.4 Naming convention

Most of the objects you are going to use will start with **"p"** prefix which stands for a **shared pointer** (**pSceneOrtographic**, **pScenePerspective**, **pCameraOrtographic**, **pCameraPerspective**, **pEntity**, **pModel**, **pLightSpot**, **pLightDirectional**, **pText**, **pTerrain**, **pMeshTerrain**,**pEmiterPoint**, **pSkybox**). **"pw"** prefix stands for **weak pointers** which are used inside fillwave as a default way of passing **"p"** objects (shared pointers) throught the scene tree. **"e"** prefix is enabled **class enum** enumerations for (**eEventType** and **eEasing** and others). Fillwave uses dual namespace design style for modules.

1.5 Rendering loop

Last step that has to be done in order to use fillwave is rendering loop creation. In each iteration a **draw**, **drawLines**, or **drawPoints** function must be called with the **"How many seconds passed since last draw"** parameter. Also there is an extra **drawTexture** function which can display if a single texture in all You want to see. GLFW example of render loop will look like:

```
void ContextGLFW1::render() {
  while (!glfwWindowShouldClose(mWindow)) {
    GLfloat timeSinceLastFrameInSec, now = glfwGetTime();

    timeSinceLastFrameInSec = now - mTimeExpired;
    mTimeExpired = now;
    mGraphicsEngine->draw(timeSinceLastFrameInSec);
```

```
8
9       /* We were writing to back buffer - make it visible */
10      glfwSwapBuffers(mWindow);
11
12      /* evaluate GLFW input events */
13      glfwPollEvents();
14    }
15  }
```

Offscreen drawing is possible using **capture** functions instead of **draw**.

```
1   void captureFramebufferToFile(const std::string& name);
2   void captureFramebufferToBuffer(GLubyte* buffer,
3                                   GLint* sizeInBytes,
4                                   GLuint format,
5                                   GLint bytesPerPixel);
```

If not sure about the format You want, default parameters for **captureFramebufferToBuffer** are **GL_RGBA** with 4 bytes per pixel. This format is also a defult one for **captureFramebufferToFile**.

2 Digging into API

2.1 Entity

pEntity is a base class for all objects which can exist in Your draw tree. You can attach any other entities to it. You can move, rotate, and scale each of them.

```
1 pEntity entity_parent = buildEntity();
2 pEntity entity_child = buildEntity();
3 entity_parent->attach(entity_child);
```

pEntity can be moved, rotated and scaled. The transformation matrix will be computed internally. However if one needs to set it directly (for example if it is computed by physics engine) there is a function provided:

```
1 void setTransformation(glm::mat4 transformationMatrix);
```

Getting a transformation matrix is also possible:

```
glm::mat4 getTransformation();
```

2.2 Scene

pScenePerspective (or **pSceneOrtographic**) by design is considered to be the root node of Your **pEntity** tree. It stores its own **pCameraPerspective** (or **pCameraOrtographic**), **pSkybox**, **pTerrain** and **pCursor**. It also has an **onHide()** and **onShow()** virtual functions which will be executed during scene change. You can chose between **Ortographic** and/or **Perspective** camera for each scene (See the next section). To set a camera in the scene use **setCamera**. To change between cameras use **setProjectionType** function.

```
/* Build a default scene */
pScene scene = buildScene();

/* Ortographic camera set */
scene->setCamera(camera0);

/* Perspective camera set */
scene->setCamera(cameraP);

/* Perspective projection is set as default. We can change it */
gScene->setProjectionType(eProjectionType::Orthographic);

/* Make our scene current one. */
engine->setCurrentScene(scene);
```

2.3 Camera

There are two camera to chose from in Fillwave: **CameraPerspective** and **CameraOrtographic**.Providing empty quaternion results will make the camera look in **-Z** direction.

```
/* Camera with perspective projection */
pCameraPerspective cameraP = pCameraPerspective ( new
    space::CameraPerspective
                glm::vec3(0.0,0.0,6.0), /* position */
                glm::quat(), /* rotation */
                glm::vec3(0.0,1.0,0.0), /* head up direction */
                glm::radians(90.0), /* field of view angle */
                screenWidth/screenHeight, /* screen ratio */
```

```
                    0.1, /* projection near plane */
                    1000.0); /* projection far plane */


/* Camera with ortographic projection */
gCameraOrthographic camera0 = pCameraOrtographic ( new
    space::CameraOrtographic(glm::vec3(0.0,0.0,6.0),
                        glm::quat(), /* rotation */
                        -10.0f, /* x left culling */
                        10.0f, /* x right culling */
                        10.0f, /* y up culling */
                        -10.0f, /* y down culling */
                        0.1f, /* z near culling */
                        1000.0f)); /* z far culling */
```

2.4 Programs and Shaders

Default programs can be built using **ProgramLoader** class using **getDefault** and **getDefaultBones** functions. See the example below:

```
/* Create loader module */
loader::ProgramLoader loader;

/* Default program */
pProgram default = loader.getDefault(gEngine);

/* Default program with animations support */
pProgram animation = loader.getDefaultBones(gEngine);
```

2.5 Store functions

Use **"store"** functions to create OpenGL objects which will be also stored by internal managers, and which will be internally, reloaded and reused if needed. Use store functions everywhere where possible.

```
/* Store the shaders providing source file path */
pShader storeShaderFragment(const std::string& path);
pShader storeShaderVertex(const std::string& path);
pShader storeShaderGeometry(const std::string& path);
pShader storeShaderTesselationControl(const std::string& path);
pShader storeShaderTesselationEvaluation(const std::string& p);

/* Store the shaders providing the source directly */
pShader storeShaderFragment(const std::string& name,
    std::string& source);
pShader storeShaderVertex(const std::string& name, std::string&
    source);
pShader storeShaderGeometry(const std::string& name,
    std::string& source);
pShader storeShaderTesselationControl(const std::string& name,
    std::string& source);
pShader storeShaderTesselationEvaluation(const std::string&
    name, std::string& source);

pProgram storeProgram(const std::string& , std::vector<pShader>);

pTexture storeTexture (const std::string&, const GLuint&);
pTexture2DRenderableDynamic
                    storeTextureDynamic (const std::string&
                        fragmentShaderPath);
pTexture3D storeTexture3D(const std::string& path,
                        const std::string& path,
                        const std::string& path,
                        const std::string& path,
                        const std::string& path);

pLightSpot storeLightSpot(glm::vec3, glm::vec4, pEntity);
pLightPoint storeLightPoint(glm::vec3, glm::vec4, pEntity);
pLightDirectional storeLightDirectional(glm::vec4, glm::vec3);

pText storeText(std::string,std::string,GLfloat,GLfloat,GLfloat);

pCursor storeCursor(pProgram, pTexture, GLfloat);
```

2.6 Model

Fillwave provides different methods to build a model. You can use **buildModel** functions or direct constructors.

2.6.1 Direct methods

```
/*
 * When the appropriate map paths are available
 * together with your model asset file.
 */

pModel model = buildModel(engine, program, "model.obj");

pModel model = pModel (new models::Model(engine, program,
    "model.obj"));

/*
 * When the appropriate map paths are available in your
 * file and you want to draw Your custom shape derived
 * from models::Shape<core::VertexBasic>
 */

models::Sphere sphere(1.0,10.0,10.0);

pModel model = buildModel(engine,
                          program,
                          sphere,
                          diffuseMap,
                          normalMap,
                          specularMap,
                          material);

pModel model = pModel(new Model(engine,
                          program,
                          sphere,
                          diffuseMap,
                          normalMap,
                          specularMap,
                          material));
```

```
38
39
40  /*
41   * When we want to explicitily provide texture paths
42   * but stll use the model asset from file.
43   */
44
45  pModel model = buildModel(engine,
46                      program,
47                      "model.obj",
48                      "relativePathToDiffuseMap",
49                      "relativePathToNormalsMap",
50                      "relativePathToSpecularMap");
51
52  pModel model = pModel (new models::Model(engine,
53                       program,
54                       "model.obj",
55                       "relativePathToDiffuseMap",
56                       "relativePathToNormalsMap",
57                       "relativePathToSpecularMap");
58
59  /*
60   * When we want to use previously created texture
61   * and material objects.
62   */
63
64  pModel model = buildModel(engine,
65                      program,
66                      "model.obj",
67                      diffuseMapTexture,
68                      normalMapTexture,
69                      specularMapTexture,
70                      material);
71  pModel model = pModel (new models::Model(engine,
72                      program,
73                      "model.obj",
74                      diffuseMapTexture,
75                      normalMapTexture,
76                      specularMapTexture,
77                      material);
```

2.6.2 Builders

Fillwave also provides two builders classes. You can use **BuilderModelExternalMaps** or **BuilderModelManual** described below.

```
/* BuilderModelExternalMaps uses custom texture maps */

/* First method */
BuilderModelExternalMaps builder1 (engine,
                                   modelPath,
                                   pProgram program,
                                   diffusePath,
                                   normalPath,
                                   specularPath);

pModel m = builder1.build();

/* Second method */
BuilderModelExternalMaps builder1(engine);

pModel = builder1.setModelPath(modelPath).
                  setProgram(program).
                  setdiffusePath(diffuseMap).
                  setNormalMapPath(normalsMap).
                  setSpecularMapPath(specularMap).
                  setMaterial(material).
                  build();



/* BuilderModelManual uses custom textures and material *
/
/* First method */

BuilderModelManual builder2 (engine,
                             modelPath,
                             program,
                             diffuseMap,
                             normalsMap,
                             specularMap,
                             material);
pModel m = builder2.build();

/* Second method */

```

```
41 BuilderModelManual builder2 (engine);
42
43 pModel = builder2.setModelPath(modelPath).
44                 setProgram(program).
45                 setDiffuseMapTexture(diffuseMap).
46                 setNormalMapTexture(normalsMap).
47                 setSpecularMapTexture(specularMap).
48                 setMaterial(material).
49                 build();
```

In each case animations will be also loaded. You can check how many of them are available, and activate one You are interested in. Default value for active animation in each model is set to "FILLWAVE_DO_NOT_ANIMATE".

```
1 void setActiveAnimation(GLint animationID)
2 GLint getAnimations();
```

2.6.3 Effects

Fillwave provides **Effects** objects which can be added to each Model. You can use built in effects: **Fog**, **BoostColor**, **ClockwiseDrawEffect**, **Painter** and **TextureOnly**. You can also create Your own one by inheriting from **Effect** class and implementing all necessary methods. Remember that during the effect execution, the models program is already used, so You can call **uniformPush** function.

```
1
2 pEffect fog(new effects::Fog());
3 pEffect boost(new effects::BoostColor(10.0));
4 pEffect ccw(new effects::ClockwiseDrawEffect());
5 pEffect paint(new effects::Painter());
6 pEffect textureOnly(new effects::TextureOnly());
7
8 model->addEffect(fog);
```

2.7 Particles

Particles system entry in Fillwave is in fact two (but powerfull) classes: **EmiterPointCPU** and **EmiterPointGPU**. The **EmiterPointGPU** particle emiter is computed entirely on GPU and uses Texture3D noise as a seed to generate random positions and velocities. It is slower but gives better robustness factors.

EmiterPointCPU emiter particles are precomputed on CPU. They are faster but the factors are less robust.

```
EmiterPointCPU::EmiterPointCPU(Engine* engine,
                               GLfloat emitingSurfaceRadius,
                               GLfloat robustness,
                               GLint howMany,
                               glm::vec4 color,
                               glm::vec3 acceleration,
                               glm::vec3 velocity,
                               glm::vec3 distance,
                               pTexture texture,
                               GLfloat lifetimeInSec,
                               GLfloat pointSize,
                               GLboolean dephTest,
                               GLfloat alphaCutOff)

pEmiterPointGPU::EmiterPointGPU(Engine* engine,
            GLfloat emitingSourceRate,
            GLuint howMany,
            glm::vec4 color,
            glm::vec3 acceleration,
            glm::vec3 startVelocity,
            glm::vec3 robustnessVelocity,
            glm::vec3 startPosition,
            glm::vec3 robustnessPosition,
            GLfloat startSize,
            GLfloat lifetime,
           pTexture texture,
           GLenum blendingSource,
           GLenum blendingDestination,
           GLboolean dephTest,
           GLfloat alphaCutOff);

/* Change the blending function if needed */
/* Default blending source is GL_SRC_ALPHA */
/* Default blending destination is GL_ONE_MINUS_SRC_ALPHA*/
void setBlendingFunction (GLenum sourcePixel, GLenum destPixel);
```

EmiterPointCPU emits particles using a round surface source. You can set the radius of this surface (**emitingSurfaceRadius**), and emiting **robustness**. **Robustness = 0** will make the particles flow perpendicular to the emiting surface. Parameter **dephTest** is critical. Using the depth test is slower but it guarantees that particles will stay visible only when they should be. Giving up

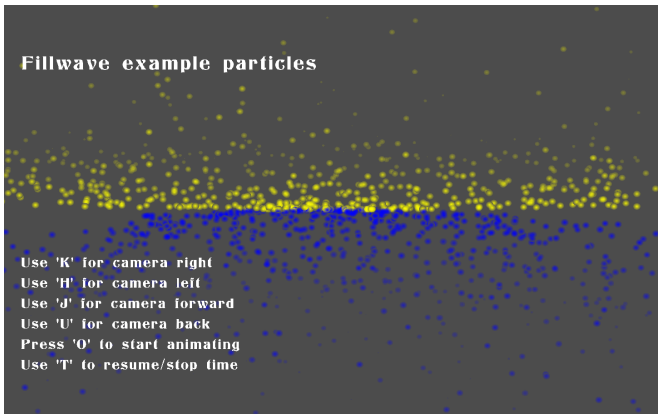


Figure 1: Particles with depth test active

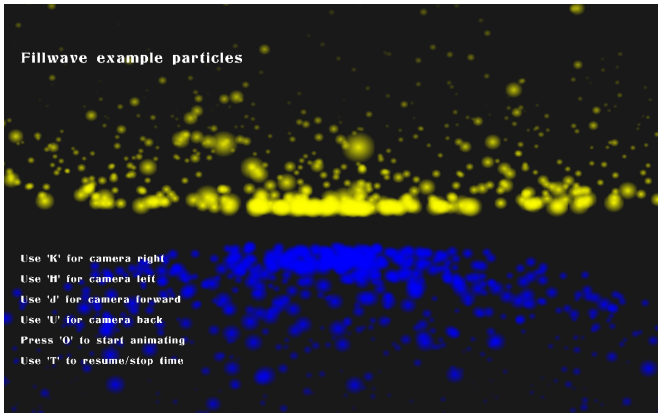


Figure 2: Particles without depth test active

the depth test will make them look much nicer and rendered faster, but they will be visible **always** which can make scene look not natural. AlphaCutOff parameter privides additional feature to discard all pixels with alpha value less than alphaCutOff.

2.8 Skybox

To create a skybox in fillwave You just need to provide texture paths as shown below.

```
1
2  pTexture3D texture=pTexture3D(new Texture3D("textures_right.png",
3                                              "textures_left.png",
4                                              "textures_ceil.png",
5                                              "textures_floor.png",
6                                              "textures_front.png",
7                                              "textures_back.png"));
8  pSkybox skybox = buildSkybox(engine,
9                               texture);
10 scene->setSkybox(skybox);
```

2.9 Terrain

Terrain in Fillwave can be generated using a voxel or quad chunks. These two methods provides complete mechanism for terrain generation.

```
1  pShader fs = engine->storeShaderFragment("default.frag");
2  pShader vs = engine->storeShaderVertex("default.vert");
3  pProgram program = buildProgram(fs + vs);
4  pTerrain terrain = buildTerrainVoxel(engine,
5                                       program,
6                                       "textures/test.png",
7                                       new terrain::MountainConstructor(),
8                                       5);
9  gScene->attach(terrain);
```

2.9.1 Voxel terrain

To create a voxel terrain You should implement a derivative **VoxelConstructor** class, and implement a **calculateActive** method. The method will take coordinates of a Voxel in VoxelChunk and decide if it should be Active or not. Active Voxels will be drawn. More information can be found in **example_terrain_voxel** and **example_terrain_quad** examples.

2.9.2 Mesh terrain

To create a terrain Mesh you should create a class derived from **TerrainConstructor** class, and implement a **calculateHeight** method. The method should take x and z coordinates in the range of (-1,1) in and return Y position.

2.10 Text

To create a 2D on screen text using ttf fonts You can use the **storeText** function.

```
pText text = engine->storeText( "Hello Fillwave",/* content */
                                "FreeMono",/* font to use */
                                -0.95, /*left bottom y start (-1,1)*/
                                -0.80, /*left bottom x start (-1,1)*/
                                100.0, /* text size */
                                eTextEffect::none); /* text effect */
```

Fillwave will look for the font in the directory relative to Your binary directory. If it will not find it, it will search the **/usr/share/fonts/truetype/freefont/** directory. Next, it will create a texture and save its metadata. Finally this texture will be used as an atlas.

2.11 Light

There are three Possible light types which can be created in Fillwave. These types are: point, spot and directional lights.

2.11.1 Spot light

Spot lights have position, intensity (RGBA) and entity parameters. When the entity is provided, the light will follow the entity whatever happens and do not consider the **position**. When there is no entity provided, spot light will keep its position as set in constructor. Spot light generates perspective shadows into the scene.

2.11.2 Directional light

Difference between spot and directional lights is a projection type. Directional lights will have an ortographic projection. It is perfect for light sources which gives constant size shadowing (Sun for example).

2.11.3 Point light

Point lights emits the light in all directions. In current revision this kind of light does not generate any shadowing effect.

2.12 Logging

All objects in Fillwave have a **log** function which prints most of the objects data to standard output. There are also predefined macros ready to use:

- **FLOG_USER** - free to use.
- **FLOG_CHECK** - checks OpenGL errors.
- **FLOG_INFO** - prints **log** function information.
- **FLOG_DEBUG** - reserved for internal debug info.
- **FLOG_ERROR** - called in case of internal engine error.
- **FLOG_FATAL** - just like FLOG_ERROR but also calls abort(). It indicates blocking errors like: "Shaders not found". If such error occurs, and the reason is not trivial then it needs further investigation by the author. Do not hesitate to contact me in such case.

To print a debug info in a certain source file You should define a module name and debug flags with macro **FLOGINIT**. Examples below:

```
1 /* Make all the messages printed */
2 FLOGINIT("My module", FERROR | FFATAL | FDEBUG | FDEBUG | FUSER)
3
4 /* Make only FLOG_FATAL and FLOG_ERROR messages printed */
5 FLOGINIT("My module", FERROR | FFATAL )\documentclass[10pt]{¢}
```

2.13 Event system

Fillwave has its own event system which bases on callbacks, and Events which are consumed by these callbacks. There are two basic types of them:

- Item callbacks
  - hierarchy callbacks
  - private callbacks
- Engine callbacks

Engine callback is designed to be called in engine context. It can modify the camera, current scene, engine configuration and so on. It is evaluated before every draw as one of the first steps in drawing pipeline. On the other hand, the **Item callback** sticks to particular entity. Difference between the **hierarchy** and **private** is that hierarchy callback executes synchronously just before the draw when the scene is drawn. As opposite, the private one is called asynchronously when the particular event is introduced into the engine (Ex. Mouse button click, or Key press). Most commonly used **ItemCallbacks** are **TimedCallbacks:**

```
TimedCallback(GLfloat timeToFinish,
              eEasing easing = eEasing::None);
TimedScaleCallback(pEntity entity,
                   glm::vec3 normalizedScaleVec,
                   GLfloat lifetime,
                   eEasing easing);
TimedRotateCallback(pEntity entity,
                    glm::vec3 axis,
                    GLfloat angle,
                    GLfloat lifeTime,
                    Easing easing);
TimedMoveCallback(pEntity entity,
                  glm::vec3 endPosition,
                  GLfloat lifeTime,
                  eEasing easing);
```

TimedCallback by itself stands only for a time delay. **TimedScaleCallback**, **TimedRotateCallback**, and **TimedMoveCallback** on the other hand can be used to modify the model scale/position/rotation in time with current easing described by enum **eEasing**. Default easing for all of the callbacks is **eEasing::None** which stands for linear interpolation.

2.13.1 Focus functions and private callbacks

Focus functionality and private callbacks were introduced to enable executing particular callbacks in particular entity without iterating over the whole scene tree. To set an entity which will receive a callback from chosen input **setFocus** functions should be used. **getFocus** functions are self-explanatory.

```
1
2  void setFocusKey(pEntity entity);
3
4  void setFocusMouseButton(pEntity entity);
5
6  void setFocusScroll(pEntity entity);
7
8  void setFocusChar(pEntity entity);
9
10 void setFocusCursorEnter(pEntity entity);
11
12 void setFocusCursorPosition(pEntity entity);
13
14 pEntity getFocusKey();
15
16 pEntity getFocusMouseButton();
17
18 pEntity getFocusScroll();
19
20 pEntity getFocusChar();
21
22 pEntity getFocusCursorEnter();
23
24 pEntity getFocusCursorPosition();
```

To attach/detach an item callback to/from an entity:

```
1 void Entity::attachHierarchyCallback(actions::ItemCallback* c);
2
3 void Entity::attachPrivateCallback(actions::ItemCallback* c);
4
5 void Entity::detachHierarchyCallback(actions::ItemCallback* c);
6
7 void Entity::detachPrivateCallback(actions::ItemCallback* c);
```

2.13.2 Register, unregister and clear functions

Any callback which is desired to be evaluated in Engine context is called **EngineCallback**. To register/unregister a engine callback in Fillwave use following functions.

```
void registerTimeCallback(actions::EngineCallback* c);

void registerKeyCallback(actions::EngineCallback* c);

void registerMouseButtonCallback(actions::EngineCallback* c);

void registerScrollCallback(actions::EngineCallback* c);

void registerCharCallback(actions::EngineCallback* c);

void registerCursorEnterCallback(actions::EngineCallback* c);

void registerCursorPositionCallback(actions::EngineCallback* c);

void registerCharacterModsCallback(actions::EngineCallback* c);

void registerTouchScreenCallback(actions::EngineCallback* c);

void unregisterTimeCallback(actions::EngineCallback* c);

void unregisterKeyCallback(actions::EngineCallback* c);

void unregisterMouseButtonCallback(actions::EngineCallback* c);

void unregisterScrollCallback(actions::EngineCallback* c);

void unregisterCharCallback(actions::EngineCallback* c);

void unregisterCursorEnterCallback(actions::EngineCallback* c);

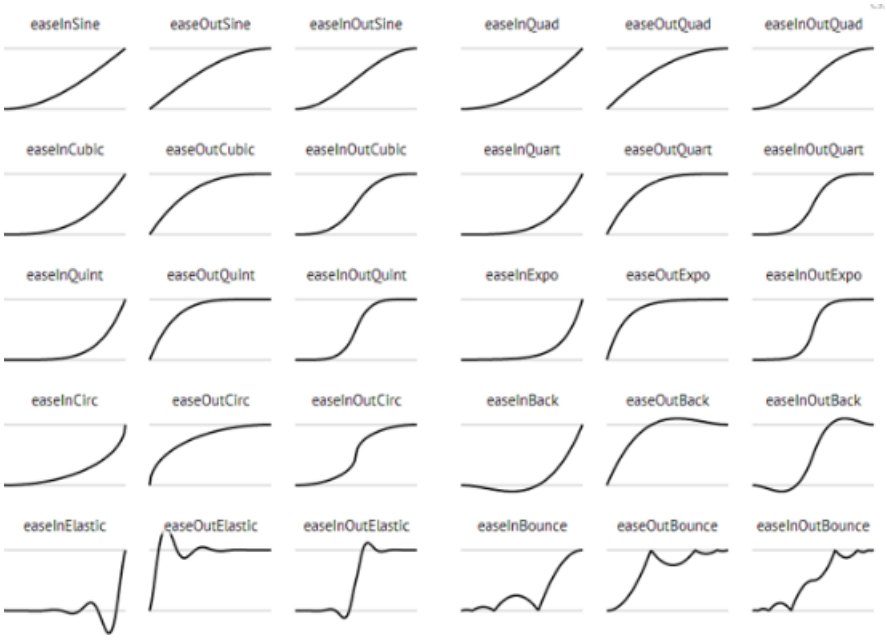
void unregisterCursorPositionCallback(actions::EngineCallback*c);

void unregisterCharacterModsCallback(actions::EngineCallback* c);

void unregisterTouchScreenCallback(actions::EngineCallback* c);
```

2.14 Easing

Timed Callbacks can be used to modify model transformation (scale, rotation and position) in time with particular easing. You can choose one of following easings define by **enum class eEasing**:



2.15 Physics

To synchronize Your graphics with physics engine just use the **setTransformation** function which is available for each entity. it overwrites all other transformations for a model.

```
1 void Entity::setTransformation(glm::mat4 modelMatrix)
```

If You have a light attached to Your model, the light will be moved together with its entity. However, only translation will be updated. If You want the light to keep the same rotation as its entity, You should use **updateParentRotation** function explicitily.

```
1 void Entity::updateParentRotation(glm::quat rotationQuaternion)
```

There is a **PhysicsMeshBuffer** defined. It can be used by physics engine to generate a collision object from a mesh polygons. Example usage of this

buffer can be found in Fillwave car racing demo - **Waveracer**. To get physics buffer from asset file use:

```
PhysicsMeshBuffer Engine::getPhysicalMeshBuffer(const
    std::string& shapePath)
```

2.16 Extras

To change the background color use:

```
void Engine::configureBackgroundColor (glm::vec3 color);
```

To apply the time factor to in Fillwave engine use:

```
void Engine::configureTime(GLfloat timeFactor); /* 1.0f as
    default */
```

To get the current executable directory use:

```
std::string Engine::getExecutablePath()
```

To set/reset current "frames per seconds" counter in right left corner use:

```
void Engine::configureFPSCounter(std::string fontName = "",
                        GLfloat xPosition = -0.95,
                        GLfloat yPosition = 0.95,
                        GLfloat size = 100.0);
```

empty or not valid font name will disable the FPS counter.
To set/reset reset file logging use:

```
void Engine::configureFileLogging(std::string fileName = "");
```

empty or not valid file name will disable the file logging.
There are few texture generators built-in in Fillwave. To use them just pass one of the patterns as a texture path in **Model** constructor or **storeTexture** function:

```
/* [R]_[G]_[B].color - for color texture */
/* [R]_[G]_[B].checkboard - for color checkboard texture */
/* "" - Black texture */

pModel model = buildModel(engine,
        programDefault,
        "model.obj",
        "255_0_0.checkboard", /* Red checkboard diffuse texture */
        "", /* black normal map */
        "255_255_255.color"); /* white specular map */
```

Debugger related API is provided to enable simple debugging of depth maps from each spot light, and to enable viewing the pickable objects if there are any of them registered in the scene. debugger can be configured using one of the following enum constants. **toggleState** is a special value which will just iterate over the possible debugger configurations.

```
enum class eDebuggerState {
   lightsSpot,
   lightsSpotColor,
   lightsSpotDepth,
   lightsPoint,
   lightsPointDepth,
   lightsPointColor,
   pickingMap,
   off,
   toggleState
};

void Engine::configureDebugger(eDebuggerState state);
```

3 Customization

3.1 Custom events

```
1
2  namespace fillwave {
3  namespace actions {
4  struct NewEventData {
5     int data;
6     const eEventType type = eEventType::custom0; /* event ID */
7  };
8
9  class NewEvent: public Event<NewEventData> {
10 public:
11    NewEvent();
12    virtual ~NewEvent();
13 };
14 } /* actions */
15 } /* fillwave */
```

3.2 Custom callbacks

```
1  namespace fillwave {
2  namespace actions {
3
4  class NewEngineCallback: public EngineCallback {
5  private:
6     float mMaximimData;
7     void sayHello() {FLOG_USER("Hello event");};
8  public:
9     NewEngineCallback(eEventType eventType, float data);
10    NewEngineCallback(float data);
11
12    virtual ~NewActionCallback();
13    void perform (Engine* engine, EventType* event);
14    };
15
16 } /* actions */
17 } /* fillwave */
```

3.3 Custom easing

TimedMoveCallbackCustom.h

```
namespace fillwave {
namespace actions {

class TimedMoveCallbackCustom: public
    fillwave::actions::TimedMoveCallback {
public:
   TimedMoveCallbackCustom(pEntity entity,
                        glm::vec3 endPosition,
                        GLfloat lifeTime);
   virtual ~TimedMoveCallbackCustom();
   GLfloat easeCustom(GLfloat progress);
};
} /* actions */
} /* fillwave */
```

TimedMoveCallbackCustom.cpp

```
namespace fillwave {
namespace actions {

TimedMoveCallbackCustom::TimedMoveCallbackCustom(pEntity entity,
                                          glm::vec3 endPosition,
                                          GLfloat
                                              lifeTime):TimedMoveCallback(entity,
                                              endPosition,lifeTime,
                                              eEasing::Custom) {

}

TimedMoveCallbackCustom::~TimedMoveCallbackCustom() {

}

GLfloat TimedMoveCallbackCustom::easeCustom(GLfloat progress) {
   /* You custom easing function goes here. For example: */
   return QuinticEaseIn(progress)*QuinticEaseIn(progress);
}

} /* actions */
} /* fillwave */
```

4 Examples

Basic example You can find below:

```
int main(int argc, char* argv[]) {
   ContextGLFW1 mContext;
   ContextGLFW1::mGraphicsEngine = new Engine(argc, argv);
   ContextGLFW1::mGraphicsEngine->insertResizeScreen(mContext.getScreenWidth(),
                                                     mContext.getScreenHeight());

   /* Scene */
   pScenePerspective scene = buildScenePerspective();

   /* Camera */
   pCameraPerspective camera = pCameraPerspective ( new
       space::CameraPerspective(glm::vec3(0.0,0.0,16.0),
                                                    glm::quat(),
                                                    glm::radians(90.0),
                                                    1.0,
                                                    0.1,
                                                    1000.0));
   /* Programs */
   loader::ProgramLoader loader;
   pProgram program =
       loader.getDefault(ContextGLFW1::mGraphicsEngine);

   /* Models */
   pModel sphere = buildModel(ContextGLFW1::mGraphicsEngine,
       program, "meshes/sphere.obj", "255_255_255.color");

   scene->attach(sphere);
   scene->setCamera(camera);
   ContextGLFW1::mGraphicsEngine->setCurrentScene(scene);

   mContext.render();
   delete ContextGLFW1::mGraphicsEngine;
   exit(EXIT_SUCCESS);
}
```

Basic example You can find below:

Main example repository

Example: Text
Example: Animation
Example: Timed callbacks with custom easing
Example: Picking
Example: Dynamic texture
Example: Effects
Example: Specular and normal maps
Example: Skybox
Example: Lights
Example: Particles
Example: Quad Terrain
Example: Voxel terrain
Example: Custom shader shape
Example: Postprocessing
Example: Ortographic projection
Example: Effects

Waveracer game draft

Example: Android activity
Example: Android JNI library
Example: Android pure native project

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 *
 *    Filip Wasil          fillwave@gmail.com
 */

 /* OpenGL
http://www.opengl.org/

* AssImp library
Open Asset Import Library (assimp)

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155
156 * fontGenerator
157 /*************************************************************************
158 | OpenGL 4 Example Code.
                                                    |
159 | Accompanies written series "Anton's OpenGL 4
       Tutorials"           |
160 | Email: anton at antongerdelan dot net
                                  |
161 | First version 5 Feb 2014
                                                  |
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       stb_image_write libraries
166 http://nothings.org/
167
168 /* stbiw-0.92 - public domain -
       http://nothings.org/stb/stb_image_write.h
169    writes out PNG/BMP/TGA images to C stdio - Sean
          Barrett 2010
170                           no warranty implied; use at
                                 your own risk
171
172
173 Before including,
```

```
174
175     #define STB_IMAGE_WRITE_IMPLEMENTATION
176
177 in the file that you want to have the implementation.
178
179
180 ABOUT:
181
182    This header file is a library for writing images to
       C stdio. It could be
183    adapted to write to memory or a general streaming
       interface; let me know.
184
185    The PNG output is not optimal; it is 20-50% larger
       than the file
186    written by a decent optimizing implementation. This
       library is designed
187    for source code compactness and simplicitly, not
       optimal image file size
188    or run-time performance.
189
190 */
```