Ride the asphalt wave!
GamePlay

Tutorial

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In this tutorial, we're going to have a close look at a little sample application that simulates a longboard moving along the pavement. The application should take input from the player and provide some sort of visual and audible feedback. How would you design and build this game? Here, we'll discuss one approach.

The Longboard sample uses the GamePlay library, which is a set of C++ classes that are designed to help you get started creating native games for the tablet. Although the classes in the GamePlay library are designed to make it particularly easy to create games for the tablet, they are also designed to make it easy to port your games to other platforms.

You will learn to
- Design the game
- Set up and initialize the game
- Update and render the game

It is suggested that readers follow along with the code in the Longboard sample.

Designing the game

For this game, the longboard doesn't appear to move until the player provides input to control the longboard's speed or tilt. Tilting the device along the x-axis controls the speed of the board and tilting it along the z-axis (like a steering wheel) controls the direction of the board. If we wanted to sketch this out on paper, it would look like:
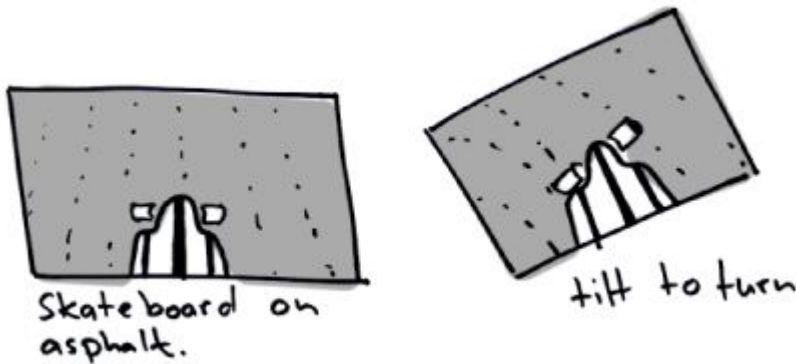
To keep the game simple, it will not track time, score, or apply any sort of limitation on the player. The longboard will simply move according to the player's inputs and visual and audible feedback will be provided.

The longboard

The longboard itself is broken up into two components, the deck and the wheels. We will make a decision here to create graphics files that represent these elements and apply them to game objects (meshes) programmatically. The position and shape of these objects will be adjusted during game time to give the appearance of motion and speed without actually moving them in 3-D space.
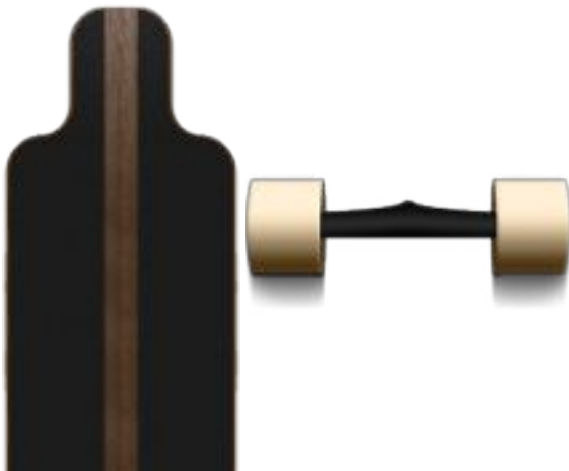
We will also apply a gradient to the overall scene to create an interesting lighting effect that focuses attention on the longboard.

The ground

Again, to keep things simple, the ground that the longboard rides upon will be a texture applied to a mesh. This mesh is transformed during the game to give the appearance of the board moving forward at varying speeds.

The sound

Lastly, the game should have some sort of audible feedback to add to the impression that the longboard is moving along the ground. A "clacking wheel" sound will be loaded into the game and its pitch adjusted based on the speed of the longboard or the sound stopped if the longboard isn't moving.

Initializing up the game   3

The foundational class in the GamePlay library is, not too surprisingly, the `Game` class. It includes the framework code you need to do many things that are common in games, such as starting and stopping the game, rendering the game frames, and maintaining basic game state. So, to create a game using GamePlay, you start by creating a class that inherits from `Game`.

For example, for the Longboard game, we create the following class:

```
class LongboardGame : public Game
```

Next, you'll almost always need to override the following methods:

```
void initialize();
void update();
void render();
void finalize();
```

There are a bunch of tasks you have to perform once and only once before your game starts. In GamePlay, you look after those tasks in the `initialize()` method. For the Longboard sample, a set of properties for the default render state is created using the `RenderState::StateBlock` class and this will be used throughout the sample. We also calculate our view/projection matrix, load some game entities, and set initial physics parameters.

Here's the code:

```
void LongboardGame::initialize()
{
    // Create our render state block that will be reused across all materials
    _stateBlock = RenderState::StateBlock::create();
    _stateBlock->setCullFace(true);
    _stateBlock->setBlend(true);
    _stateBlock->setBlendSrc(RenderState::BLEND_SRC_ALPHA);
    _stateBlock->setBlendDst(RenderState::BLEND_ONE_MINUS_SRC_ALPHA);

    // Calculate initial matrices
    Matrix::createPerspective(45.0f, (float)getWidth() / (float)getHeight(),
        0.25f, 100.0f, &_projectionMatrix);
    Matrix::createLookAt(0, 1.75f, 1.35f, 0, 0, -0.15f, 0, 0.20f,
        -0.80f, &_viewMatrix);
    Matrix::multiply(_projectionMatrix, _viewMatrix, &_viewProjectionMatrix);

    // Build game entities
    buildGround();
    buildBoard();
    buildWheels();
    buildGradient();

    // Set initial board physics
    _direction.set(0, 0, -1);
    _velocity = VELOCITY_MIN_MS;
}
```

A lot of the initialization work is hidden behind the build methods that create the game entities. It's also in those methods where you'll see more of the power of the GamePlay library.

The game entities (things that appear in the game) are built using OpenGL ES 2.0 under the covers. We won't cover OpenGL ES in this tutorial, but you can check out the following resources on the web for more information:

* OpenGL ES 2.0 Reference Pages
* OpenGL ES 2.0 Programming Guide
* OpenGL ES 2_X - The Standard for Embedded Accelerated 3D Graphics

What we will cover is the interface the GamePlay library provides on top of OpenGL ES. The geometry of a 3-D object in OpenGL is specified as a set of triangles. That set of triangles, taken together, are called a mesh. Some other names for a mesh are a model, an entity, or an object.

GamePlay includes a `Mesh` class that has a number of methods that make it easier to manage meshes. One such method, `createQuad()`, lets you create a quadrilateral (four sided mesh or a plane) with a single call, which saves you from building it out of two triangles. That call is used to build the mesh that represents all the objects in our longboard sample (board, wheels, ground, and gradient).

For example, here's the code for `buildGround()`. Notice that GamePlay provides a `Vector3` support class. Here, `WORLD_SIZE` is just a constant that specifies - surprise, surprise - the extent of the game world.

```
void LongboardGame::buildGround()
{
    Mesh* groundMesh = Mesh::createQuad(Vector3(-WORLD_SIZE, 0, -WORLD_SIZE),
                                        Vector3(-WORLD_SIZE, 0, WORLD_SIZE),
                                        Vector3(WORLD_SIZE, 0, -WORLD_SIZE),
                                        Vector3(WORLD_SIZE, 0, WORLD_SIZE) );
}
```

That looks after the basic geometry. Next, we have to specify the material that the ground is actually made of. In OpenGL, a material is really a statement of how an object interacts with light. GamePlay lets you create a material by either specifying an effect (using the `Effect` class) or by specifying a vertex and fragment shader program. In this sample, we specify shader programs.

```
_ground = Model::create(groundMesh);

Material* groundMaterial =
    Material::createMaterial("res/shaders/textured.vsh","res/shaders/textured.fsh");

groundMaterial->setStateBlock(_stateBlock);
```

An OpenGL vertex shader is a set of instructions, written in the GL shader language (GLSL), that describes how to transform vertex data during the rendering process. For example, you can alter the positions of vertices so that the shape they define appears to flutter in the wind. You can manipulate depth and color information in the vertex shader.

The following code implements the vertex shader used with the ground material (textured.vsh).

```
uniform mat4 u_worldViewProjectionMatrix;

attribute vec3 a_position;
attribute vec3 a_normal;
attribute vec2 a_texCoord;

varying vec3 v_normal;
varying vec2 v_texCoord;

void main()
{
    gl_Position = u_worldViewProjectionMatrix * vec4(a_position, 1);
    v_normal = a_normal;
    v_texCoord = a_texCoord;
}
```

Next, we specify the fragment shader, textured.fsh. A fragment shader is like a vertex shader except that it manipulates sets of pixels and their properties instead of vertex data. You can, for example, use fragment shaders to cause blur effects or sepia tone effects.

```
precision highp float;

varying vec3 v_normal;
varying vec2 v_texCoord;

uniform sampler2D u_texture;
uniform vec2 u_textureRepeat;
uniform vec2 u_textureTransform;

void main()
{
    gl_FragColor = texture2D(u_texture, v_texCoord * u_textureRepeat +
u_textureTransform);
}
```

We also set the render state of the ground material using the setStateBlock() function. After specifying the material of the ground, we specify its texture. GamePlay provides a Texture class that is designed to make this really easy. We just construct a Texture object, groundTexture, by specifying the location of a PNG file that we want to apply to the mesh. The second parameter, a Boolean, indicates whether or not mipmaps should be generated. Mipmaps are precalculated, resized versions of the original texture image. Using mipmapping speeds up rendering and reduces artifacts caused by anti-aliasing.

```
Texture::Sampler* groundSampler = groundMaterial->
    getParameter("u_texture")->setValue("res/textures/tileable_asphalt.png", true)
```

Next, we set the wrap mode of the texture. The first true parameter specifies that the texture should repeat horizontally, the second true parameter says to also repeat vertically. This allows the ground texture to fill the screen.

```
groundSampler->setWrapMode(Texture::REPEAT, Texture::REPEAT);
```

Next, we set other texture characteristics for the material that we just created.

```
groundMaterial->getParameter("u_worldViewProjectionMatrix")-
>setValue(&_groundWorldViewProjectionMatrix);
groundMaterial->getParameter("u_textureRepeat")->setValue(Vector2(WORLD_SIZE/2,
WORLD_SIZE/2));
groundMaterial->getParameter("u_textureTransform")->setValue(&_groundUVTransform);
```

Lastly, we release all of the objects that are owned by mesh instances.

```
SAFE_RELEASE(groundMesh);
```

This setup is repeated for the board, wheels, and gradient.

Updating the game

A key part of this sample and any game or animation is gathering user input and updating the state of the game so that the input is reflected when the game world is rendered.

So, in the overridden `update()` method, you have to gather input and update game state. For the Longboard sample, you need to know how the user has moved the tablet. GamePlay uses the terms pitch and roll, which are commonly used when describing the motion of an aircraft, for the two motions we need to capture.

In GamePlay, you can get the pitch and roll with a single method call: `getAccelerometerPitchAndRoll(&pitch,&roll)`. In the code snippet below, the pitch and roll are read and clamped so they fall between a preset maximum and minimum value.

```
void LongboardGame::update(long elapsedTime)
{
    // Query the accelerometer
    float pitch, roll;
    Input::getAccelerometerPitchAndRoll(&pitch, &roll);

    // Clamp angles
    pitch = fmax(fmin(pitch, PITCH_MAX), PITCH_MIN);
    roll = fmax(fmin(roll, ROLL_MAX), -ROLL_MAX);
}
```

Next, the throttle is calculated based on the pitch angle of the tablet. You can think of the throttle value as representing how far down the gas pedal is pressed. The sound of the clacking wheels is then adjusted to match the throttle and the velocity of the board is updated accordingly. Notice that we're using a really simple formula for velocity here that ignores acceleration. In games, you don't have to apply real physics; sometimes it's just not necessary. In fact, in some cases making the physics too realistic can ruin the playability of a game.

```
float throttle = 1.0f - ((pitch - MIN_PITCH) / PITCH_RANGE);

if (throttle > 0.0f)
{
    if (_wheelsSound->getState() != AudioSource::PLAYING)
        _wheelsSound->play();

        _wheelsSound->setPitch(throttle);
}
else
{
    _wheelsSound->stop();
}

_velocity = VELOCITY_MIN_MS + ((VELOCITY_MAX_MS - VELOCITY_MIN_MS) * throttle);
```

To look after direction, we create a `Matrix` object. We then use the `createRotationY()` method to populate the matrix so that it represents a rotation about the y-axis. The calculation takes into account the roll input value that we retrieved above and the maximum turn rate. The direction of the longboard is stored in a `Vector3` object and was initialized to (0,0,1). So, we apply the rotation matrix to the direction vector and then renormalize it. The result is a unit vector that points in the new direction.

```
static Matrix rotMat;
Matrix::createRotationY(-MATH_DEG_TO_RAD((TURN_RATE_MAX_MS * elapsedTime) *
    (roll / ROLL_MAX) * throttle), &rotMat);
rotMat.transformVector(&_direction);
_direction.normalize();
```

Next we transform the ground, the longboard wheels, and the board itself (including tilting it appropriately).
Again, we use the matrices and matrix operations provided by the GamePlay library. In this case, that includes
some perspective matrices. Note that we don't actually move the board itself, but instead we move the ground
under it to simulate the board moving.

```
Matrix::multiply(rotMat, _groundWorldMatrix, &_groundWorldMatrix);
Matrix::multiply(_viewProjectionMatrix, _groundWorldMatrix,
&_groundWorldViewProjectionMatrix);


Matrix::createScale(1.2f, 1.2f, 1.2f, &_wheelsWorldMatrix);
_wheelsWorldMatrix.translate(-roll / ROLL_MAX * 0.05f, 0, 0.05f);
_wheelsWorldMatrix.rotateY(MATH_DEG_TO_RAD(roll * 0.45f));
Matrix::multiply(_viewProjectionMatrix, _wheelsWorldMatrix,
&_wheelsWorldViewProjectionMatrix);


Matrix::createScale(1.25f, 1.25f, 1.25f, &_boardWorldMatrix);
_boardWorldMatrix.translate(0, 0, 0.65f);
_boardWorldMatrix.rotateZ(MATH_DEG_TO_RAD(roll * 0.5f));
_boardWorldMatrix.rotateY(MATH_DEG_TO_RAD(roll * 0.1f));
Matrix::multiply(_viewProjectionMatrix, _boardWorldMatrix,
&_boardWorldViewProjectionMatrix);
```

Using the following code, we make it look like the board is moving by transforming the ground's texture
coordinates.

```
_groundUVTransform.x += -_direction.x * (_velocity * elapsedTime);
_groundUVTransform.y += -_direction.z * (_velocity * elapsedTime);
if (_groundUVTransform.x >= 1.0f)
{
    _groundUVTransform.x = 1.0f - _groundUVTransform.x;
}
if (_groundUVTransform.y >= 1.0f)
{
    _groundUVTransform.y = 1.0f - _groundUVTransform.y;
}
```

Rendering the game

The `render()` method for our sample is just a few lines of code. We need all of our game entities to render —or draw— themselves on the screen. So, we clear the color and depth buffers and call each game entity's `draw()` method.

```
void LongboardGame::render()
{
    // Clear the color and depth buffers.
    clear(CLEAR_COLOR, Vector4::one(), 1.0f, 0);

    // Draw the scene
    _ground->draw();
    _wheels->draw();
    _board->draw();
    _gradient->draw();
}
```

Again, GamePlay abstracts away a complex process - that of rendering a game entity in this case. Under the covers, these objects are represented by instances of the `MeshInstance` class.

So that's it, the game has been set up, updated, and rendered and is now ready to launch and play!

Try it yourself

The GamePlay library is designed to make it really easy to create simple games. After you understand how the Longboard sample is put together, try changing some things. Start with simple stuff, such as the texture files or some of the constants. When you really have the hang of things, try creating your own game from scratch using Longboard nearby as a cheat sheet. Have fun!

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