原 SDL2源代码分析6：复制到渲染器（SDL_RenderCopy()）

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上一篇文章分析了SDL更新纹理像素数据的函数SDL_UpdateTexture()。这篇文章继续分析SDL的源代码。本文分析SDL纹理复制到渲染目标的函数SDL_RenderCopy()。

SDL播放视频的代码流程如下所示。

初始化:

SDL_Init(): 初始化SDL。

SDL_CreateWindow(): 创建窗口（Window）。

SDL_CreateRenderer(): 基于窗口创建渲染器（Render）。

SDL_CreateTexture(): 创建纹理（Texture）。

循环渲染数据:

SDL_UpdateTexture(): 设置纹理的数据。

SDL_RenderCopy(): 纹理复制给渲染器。

SDL_RenderPresent(): 显示。

上篇文章分析了该流程中的第5个函数SDL_UpdateTexture()。本文继续分析该流程中的第6个函数SDL_RenderCopy()。

SDL_RenderCopy()

函数简介

SDL使用SDL_RenderCopy()将纹理数据复制给渲染目标。SDL_RenderCopy()的原型如下。

```cpp
int SDLCALL SDL_RenderCopy(SDL_Renderer * renderer,
                           SDL_Texture * texture,
                           const SDL_Rect * srcrect,
                           const SDL_Rect * dstrect);
```

参数的含义如下。

renderer：渲染目标。

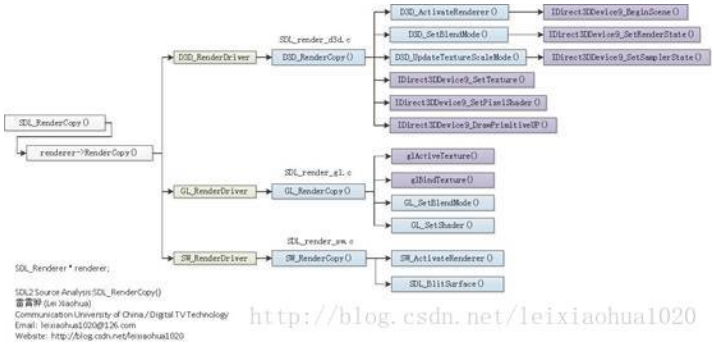
texture：输入纹理。

srcrect：选择输入纹理的一块矩形区域作为输入。设置为NULL的时候整个纹理作为输入。
dstrect：选择渲染目标的一块矩形区域作为输出。设置为NULL的时候整个渲染目标作为输出。

成功的话返回0，失败的话返回-1。

函数调用关系图

SDL_RenderCopy()关键函数的调用关系可以用下图表示。



上面的图片不太清晰，更清晰的图片上传到了相册里面：

http://my.csdn.net/leixiaohua1020/album/detail/1793911

把相册里面的图片保存下来就可以得到清晰的图片了。

源代码分析

SDL_RenderCopy()的源代码位于render\SDL_render.c中，如下所示。

```cpp
int SDL_RenderCopy(SDL_Renderer * renderer, SDL_Texture * texture,
               const SDL_Rect * srcrect, const SDL_Rect * dstrect)
{
    SDL_Rect real_srcrect = { 0, 0, 0, 0 };
    SDL_Rect real_dstrect = { 0, 0, 0, 0 };
    SDL_FRect frect;


    CHECK_RENDERER_MAGIC(renderer, -1);
    CHECK_TEXTURE_MAGIC(texture, -1);


    if (renderer != texture->renderer) {
        return SDL_SetError("Texture was not created with this renderer");
    }


    real_srcrect.x = 0;
    real_srcrect.y = 0;
    real_srcrect.w = texture->w;
    real_srcrect.h = texture->h;
    if (srcrect) {
        if (!SDL_IntersectRect(srcrect, &real_srcrect, &real_srcrect)) {
            return 0;
        }
    }


    SDL_RenderGetViewport(renderer, &real_dstrect);
    real_dstrect.x = 0;
    real_dstrect.y = 0;
    if (dstrect) {
        if (!SDL_HasIntersection(dstrect, &real_dstrect)) {
            return 0;
        }
        real_dstrect = *dstrect;
    }


    if (texture->native) {
        texture = texture->native;
    }


    /* Don't draw while we're hidden */
    if (renderer->hidden) {
        return 0;
    }


    frect.x = real_dstrect.x * renderer->scale.x;
    frect.y = real_dstrect.y * renderer->scale.y;
    frect.w = real_dstrect.w * renderer->scale.x;
    frect.h = real_dstrect.h * renderer->scale.y;


    return renderer->RenderCopy(renderer, texture, &real_srcrect, &frect);
}
```

从源代码中可以看出，SDL_RenderCopy()的大致流程如下。

1. **检查输入参数的合理性。**
2. **调用SDL_Render的RenderCopy ()方法复制纹理到渲染目标。** 这一步是整个函数的核心。

下面我们详细看一下几种不同的渲染器的RenderCopy()的方法。

1. Direct3D

Direct3D 渲染器中对应RenderCopy()的函数是D3D_RenderCopy()，它的源代码如下所示（位于render\direct3d\SDL_render_d3d.c）。

```cpp
static int D3D_RenderCopy(SDL_Renderer * renderer, SDL_Texture * texture,
               const SDL_Rect * srcrect, const SDL_FRect * dstrect)
{
    D3D_RenderData *data = (D3D_RenderData *) renderer->driverdata;
    D3D_TextureData *texturedata;
    LPDIRECT3DPIXELSHADER9 shader = NULL;
    float minx, miny, maxx, maxy;
    float minu, maxu, minv, maxv;
    DWORD color;
    Vertex vertices[4];
    HRESULT result;
```

```
    if (D3D_ActivateRenderer(renderer) < 0) {
        return -1;
    }


    texturedata = (D3D_TextureData *)texture->driverdata;
    if (!texturedata) {
        SDL_SetError("Texture is not currently available");
        return -1;
    }


    minx = dstrect->x - 0.5f;
    miny = dstrect->y - 0.5f;
    maxx = dstrect->x + dstrect->w - 0.5f;
    maxy = dstrect->y + dstrect->h - 0.5f;


    minu = (float) srcrect->x / texture->w;
    maxu = (float) (srcrect->x + srcrect->w) / texture->w;
    minv = (float) srcrect->y / texture->h;
    maxv = (float) (srcrect->y + srcrect->h) / texture->h;


    color = D3DCOLOR_ARGB(texture->a, texture->r, texture->g, texture->b);


    vertices[0].x = minx;
    vertices[0].y = miny;
    vertices[0].z = 0.0f;
    vertices[0].color = color;
    vertices[0].u = minu;
    vertices[0].v = minv;


    vertices[1].x = maxx;
    vertices[1].y = miny;
    vertices[1].z = 0.0f;
    vertices[1].color = color;
    vertices[1].u = maxu;
    vertices[1].v = minv;


    vertices[2].x = maxx;
    vertices[2].y = maxy;
    vertices[2].z = 0.0f;
    vertices[2].color = color;
    vertices[2].u = maxu;
    vertices[2].v = maxv;


    vertices[3].x = minx;
    vertices[3].y = maxy;
    vertices[3].z = 0.0f;
    vertices[3].color = color;
    vertices[3].u = minu;
    vertices[3].v = maxv;


    D3D_SetBlendMode(data, texture->blendMode);


    D3D_UpdateTextureScaleMode(data, texturedata, 0);


    result =
        IDirect3DDevice9_SetTexture(data->device, 0, (IDirect3DBaseTexture9 *)
                                    texturedata->texture);
    if (FAILED(result)) {
        return D3D_SetError("SetTexture()", result);
    }


    if (texturedata->yuv) {
        shader = data->ps_yuv;


        D3D_UpdateTextureScaleMode(data, texturedata, 1);
        D3D_UpdateTextureScaleMode(data, texturedata, 2);


        result =
            IDirect3DDevice9_SetTexture(data->device, 1, (IDirect3DBaseTexture9 *)
                                        texturedata->utexture);
        if (FAILED(result)) {
            return D3D_SetError("SetTexture()", result);
        }


        result
```

```
        result =
            IDirect3DDevice9_SetTexture(data->device, 2, (IDirect3DBaseTexture9 *)
                                        texturedata->vtexture);
        if (FAILED(result)) {
            return D3D_SetError("SetTexture()", result);
        }
    }


    if (shader) {
        result = IDirect3DDevice9_SetPixelShader(data->device, shader);
        if (FAILED(result)) {
            return D3D_SetError("SetShader()", result);
        }
    }
    result =
        IDirect3DDevice9_DrawPrimitiveUP(data->device, D3DPT_TRIANGLEFAN, 2,
                                         vertices, sizeof(*vertices));
    if (FAILED(result)) {
        return D3D_SetError("DrawPrimitiveUP()", result);
    }
    if (shader) {
        result = IDirect3DDevice9_SetPixelShader(data->device, NULL);
        if (FAILED(result)) {
            return D3D_SetError("SetShader()", result);
        }
    }
    return 0;
}
```

从代码中可以看出，D3D_RenderCopy()函数按照执行的顺序调用了如下函数：

D3D_ActivateRenderer()：激活渲染器。其内部使用Direct3D的API函数IDirect3DDevice9_BeginScene()开始一个D3D的场景。
D3D_SetBlendMode()：设置渲染器状态。其内部使用Direct3D的API函数IDirect3DDevice9_SetRenderState()设置渲染器的状态。
D3D_UpdateTextureScaleMode()：设置纹理采样方式。其内部调用使用Direct3D的API函数IDirect3DDevice9_SetSamplerState()设置D3D的纹理采样方式。
IDirect3DDevice9_SetTexture()：Direct3D的API，用于设置当前启用的纹理。
IDirect3DDevice9_SetPixelShader()：Direct3D的API，用于设置使用的像素着色器。
IDirect3DDevice9_DrawPrimitiveUP()：Direct3D的API，用于渲染。

上述几个函数中，前3个函数是SDL中的函数，后3个函数是Direct3D的API。在此附上前三个函数的代码。

D3D_ActivateRenderer()：激活渲染器。

```cpp
static int D3D_ActivateRenderer(SDL_Renderer * renderer)
{
    D3D_RenderData *data = (D3D_RenderData *) renderer->driverdata;
    HRESULT result;


    if (data->updateSize) {
        SDL_Window *window = renderer->window;
        int w, h;


        SDL_GetWindowSize(window, &w, &h);
        data->pparams.BackBufferWidth = w;
        data->pparams.BackBufferHeight = h;
        if (SDL_GetWindowFlags(window) & SDL_WINDOW_FULLSCREEN) {
            data->pparams.BackBufferFormat =
                PixelFormatToD3DFMT(SDL_GetWindowPixelFormat(window));
        } else {
            data->pparams.BackBufferFormat = D3DFMT_UNKNOWN;
        }
        if (D3D_Reset(renderer) < 0) {
            return -1;
        }


        data->updateSize = SDL_FALSE;
    }
    if (data->beginScene) {
        result = IDirect3DDevice9_BeginScene(data->device);
        if (result == D3DERR_DEVICELOST) {
            if (D3D_Reset(renderer) < 0) {
                return -1;
            }
            result = IDirect3DDevice9_BeginScene(data->device);
        }
        if (FAILED(result)) {
            return D3D_SetError("BeginScene()", result);
        }
        data->beginScene = SDL_FALSE;
    }
    return 0;
}
```

D3D_SetBlendMode()：设置渲染器状态。

```cpp
static void D3D_SetBlendMode(D3D_RenderData * data, int blendMode)
{
    switch (blendMode) {
    case SDL_BLENDMODE_NONE:
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_ALPHABLENDENABLE,
                                        FALSE);
        break;
    case SDL_BLENDMODE_BLEND:
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_ALPHABLENDENABLE,
                                        TRUE);
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_SRCBLEND,
                                        D3DBLEND_SRCALPHA);
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_DESTBLEND,
                                        D3DBLEND_INVSRCALPHA);
        if (data->enableSeparateAlphaBlend) {
            IDirect3DDevice9_SetRenderState(data->device, D3DRS_SRCBLENDALPHA,
                                            D3DBLEND_ONE);
            IDirect3DDevice9_SetRenderState(data->device, D3DRS_DESTBLENDALPHA,
                                            D3DBLEND_INVSRCALPHA);
        }
        break;
    case SDL_BLENDMODE_ADD:
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_ALPHABLENDENABLE,
                                        TRUE);
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_SRCBLEND,
                                        D3DBLEND_SRCALPHA);
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_DESTBLEND,
                                        D3DBLEND_ONE);
        if (data->enableSeparateAlphaBlend) {
            IDirect3DDevice9_SetRenderState(data->device, D3DRS_SRCBLENDALPHA,
                                            D3DBLEND_ZERO);
            IDirect3DDevice9_SetRenderState(data->device, D3DRS_DESTBLENDALPHA,
                                            D3DBLEND_ONE);
        }
        break;
    case SDL_BLENDMODE_MOD:
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_ALPHABLENDENABLE,
                                        TRUE);
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_SRCBLEND,
                                        D3DBLEND_ZERO);
        IDirect3DDevice9_SetRenderState(data->device, D3DRS_DESTBLEND,
                                        D3DBLEND_SRCCOLOR);
        if (data->enableSeparateAlphaBlend) {
            IDirect3DDevice9_SetRenderState(data->device, D3DRS_SRCBLENDALPHA,
                                            D3DBLEND_ZERO);
            IDirect3DDevice9_SetRenderState(data->device, D3DRS_DESTBLENDALPHA,
                                            D3DBLEND_ONE);
        }
        break;
    }
}
```

D3D_UpdateTextureScaleMode()：设置纹理采样方式。

```cpp
static void D3D_UpdateTextureScaleMode(D3D_RenderData *data, D3D_TextureData *texturedata, unsigned index)
{
    if (texturedata->scaleMode != data->scaleMode[index]) {
        IDirect3DDevice9_SetSamplerState(data->device, index, D3DSAMP_MINFILTER,
                                         texturedata->scaleMode);
        IDirect3DDevice9_SetSamplerState(data->device, index, D3DSAMP_MAGFILTER,
                                         texturedata->scaleMode);
        data->scaleMode[index] = texturedata->scaleMode;
    }
}
```

2. OpenGL

OpenGL渲染器中对应RenderCopy()的函数是GL_RenderCopy()，它的源代码如下所示（位于render\opengl\SDL_render_gl.c）。

```cpp
static int GL_RenderCopy(SDL_Renderer * renderer, SDL_Texture * texture,
               const SDL_Rect * srcrect, const SDL_FRect * dstrect)
{
    GL_RenderData *data = (GL_RenderData *) renderer->driverdata;
    GL_TextureData *texturedata = (GL_TextureData *) texture->driverdata;
    GLfloat minx, miny, maxx, maxy;
    GLfloat minu, maxu, minv, maxv;


    GL_ActivateRenderer(renderer);


    data->glEnable(texturedata->type);
    if (texturedata->yuv) {
        data->glActiveTextureARB(GL_TEXTURE2_ARB);
        data->glBindTexture(texturedata->type, texturedata->vtexture);


        data->glActiveTextureARB(GL_TEXTURE1_ARB);
        data->glBindTexture(texturedata->type, texturedata->utexture);


        data->glActiveTextureARB(GL_TEXTURE0_ARB);
    }
    data->glBindTexture(texturedata->type, texturedata->texture);


    if (texture->modMode) {
        GL_SetColor(data, texture->r, texture->g, texture->b, texture->a);
    } else {
        GL_SetColor(data, 255, 255, 255, 255);
    }


    GL_SetBlendMode(data, texture->blendMode);


    if (texturedata->yuv) {
        GL_SetShader(data, SHADER_YV12);
    } else {
        GL_SetShader(data, SHADER_RGB);
    }


    minx = dstrect->x;
    miny = dstrect->y;
    maxx = dstrect->x + dstrect->w;
    maxy = dstrect->y + dstrect->h;


    minu = (GLfloat) srcrect->x / texture->w;
    minu *= texturedata->texw;
    maxu = (GLfloat) (srcrect->x + srcrect->w) / texture->w;
    maxu *= texturedata->texw;
    minv = (GLfloat) srcrect->y / texture->h;
    minv *= texturedata->texh;
    maxv = (GLfloat) (srcrect->y + srcrect->h) / texture->h;
    maxv *= texturedata->texh;


    data->glBegin(GL_TRIANGLE_STRIP);
    data->glTexCoord2f(minu, minv);
    data->glVertex2f(minx, miny);
    data->glTexCoord2f(maxu, minv);
    data->glVertex2f(maxx, miny);
    data->glTexCoord2f(minu, maxv);
    data->glVertex2f(minx, maxy);
    data->glTexCoord2f(maxu, maxv);
    data->glVertex2f(maxx, maxy);
    data->glEnd();


    data->glDisable(texturedata->type);


    return GL_CheckError("", renderer);
}
```

从代码中可以看出，GL_RenderCopy()函数调用了OpenGL的API函数glActiveTexture()，glBindTexture()创建了一个纹理。并且使用GL_SetBlendMode()，GL_SetShader()设置了有关的一些参数。

有一点需要注意，在OpenGL渲染器中，如果输入像素格式是YUV，就会使用3个纹理。

3. Software

Software渲染器中对应RenderCopy()的函数是SW_RenderCopy()，它的源代码如下所示（位于render\software\SDL_render_sw.c）。

```cpp
static int SW_RenderCopy(SDL_Renderer * renderer, SDL_Texture * texture,
               const SDL_Rect * srcrect, const SDL_FRect * dstrect)
{
    SDL_Surface *surface = SW_ActivateRenderer(renderer);
    SDL_Surface *src = (SDL_Surface *) texture->driverdata;
    SDL_Rect final_rect;


    if (!surface) {
        return -1;
    }


    if (renderer->viewport.x || renderer->viewport.y) {
        final_rect.x = (int)(renderer->viewport.x + dstrect->x);
        final_rect.y = (int)(renderer->viewport.y + dstrect->y);
    } else {
        final_rect.x = (int)dstrect->x;
        final_rect.y = (int)dstrect->y;
    }
    final_rect.w = (int)dstrect->w;
    final_rect.h = (int)dstrect->h;


    if ( srcrect->w == final_rect.w && srcrect->h == final_rect.h ) {
        return SDL_BlitSurface(src, srcrect, surface, &final_rect);
    } else {
        return SDL_BlitScaled(src, srcrect, surface, &final_rect);
    }
}
```

该函数的源代码还没有详细分析。

文章标签： SDL Direct3D OpenGL GDI 渲染

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