

原 SDL2源代码分析4：纹理（SDL_Texture）

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SDL源代码分析系列文章列表：

[SDL2源代码分析1：初始化（SDL_Init\(\)）](#)

[SDL2源代码分析2：窗口（SDL_Window）](#)

[SDL2源代码分析3：渲染器（SDL_Renderer）](#)

[SDL2源代码分析4：纹理（SDL_Texture）](#)

[SDL2源代码分析5：更新纹理（SDL_UpdateTexture\(\)）](#)

[SDL2源代码分析6：复制到渲染器（SDL_RenderCopy\(\)）](#)

[SDL2源代码分析7：显示（SDL_RenderPresent\(\)）](#)

[SDL2源代码分析8：视频显示总结](#)

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上一篇文章分析了SDL中创建渲染器的函数SDL_CreateRenderer()。这篇文章继续分析SDL的源代码。本文分析SDL的纹理（SDL_Texture）。



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3个函数SDL_CreateRenderer()。本文继续分析该流程中的第4个函数SDL_CreateTexture()。

SDL_Texture

SDL_Texture结构定义了一个SDL中的纹理。如果直接使用SDL2编译好的SDK的话，是看不到SDL_Texture的内部结构的。有关它的定义在头文件中只有一行代码，如下所示。

```
[cpp]
1.  /**
2.   * \brief An efficient driver-specific representation of pixel data
3.   */
4.  struct SDL_Texture;
5.  typedef struct SDL_Texture SDL_Texture;
```

在源代码工程中可以看到SDL_Texture的定义，位于render\SDL_sysrender.h文件中。它的定义如下。

```
[cpp]
1.  /* Define the SDL texture structure */
2.  struct SDL_Texture
3.  {
4.      const void *magic;
5.      Uint32 format;           /**< The pixel format of the texture */
6.      int access;             /**< SDL_TextureAccess */
7.      int w;                  /**< The width of the texture */
8.      int h;                  /**< The height of the texture */
9.      int modMode;            /**< The texture modulation mode */
10.     SDL_BlendMode blendMode; /**< The texture blend mode */
11.     Uint8 r, g, b, a;        /**< Texture modulation values */
12.
13.
14.     SDL_Renderer *renderer;
15.
16.
17.     /* Support for formats not supported directly by the renderer */
18.     SDL_Texture *native;
19.     SDL_SW_YUVTexture *yuv;
20.     void *pixels;
21.     int pitch;
22.     SDL_Rect locked_rect;
23.
24.
25.     void *driverdata;         /**< Driver specific texture representation */
26.
27.
28.     SDL_Texture *prev;
29.     SDL_Texture *next;
30. };
```

可以看出其中包含了一个“纹理”所具备的各种属性。下面来看看如何创建这个SDL_Texture。

SDL_CreateTexture()

函数简介

使用SDL_CreateTexture()基于渲染器创建一个纹理。SDL_CreateTexture()的原型如下。

```
[cpp]
1.  SDL_Texture * SDLCALL SDL_CreateTexture(SDL_Renderer * renderer,
2.                                          Uint32 format,
3.                                          int access, int w,
4.                                          int h);
```

参数的含义如下。

renderer：目标渲染器。

format

：纹理的格式。后面会详述。

access

：可以取以下值（定义位于SDL_TextureAccess中）

SDL_TEXTUREACCESS_STATIC

：变化极少

SDL_TEXTUREACCESS_STREAMING

：变化频繁

SDL_TEXTUREACCESS_TARGET

：暂时没有理解

w

：纹理的宽

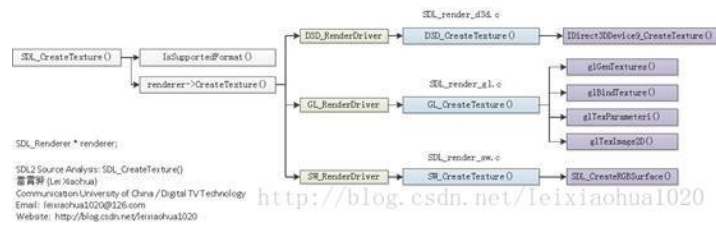
h

：纹理的高

创建成功则返回纹理的ID，失败返回0。

函数调用关系图

SDL_CreateTexture ()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/1793543>

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

```
[cpp]
1.  SDL_Texture * SDL_CreateTexture(SDL_Renderer * renderer, Uint32 format, int access, int w, int h)
2.  {
3.      SDL_Texture *texture;
4.
5.
6.      CHECK_RENDERER_MAGIC(renderer, NULL);
7.
8.
9.      if (!format) {
10.         format = renderer->info.texture_formats[0];
11.     }
12.     if (SDL_ISPIXELFORMAT_INDEXED(format)) {
13.         SDL_SetError("Palettized textures are not supported");
14.         return NULL;
15.     }
16.     if (w <= 0 || h <= 0) {
17.         SDL_SetError("Texture dimensions can't be 0");
18.         return NULL;
19.     }
20.     if ((renderer->info.max_texture_width && w > renderer->info.max_texture_width) ||
21.         (renderer->info.max_texture_height && h > renderer->info.max_texture_height)) {
22.         SDL_SetError("Texture dimensions are limited to %dx%d", renderer->info.max_texture_width, renderer->info.max_texture_height);
23.         return NULL;
24.     }
25.     texture = (SDL_Texture *) SDL_malloc(1, sizeof(*texture));
26.     if (!texture) {
27.         SDL_OutOfMemory();
28.         return NULL;
29.     }
30.     texture->magic = &texture_magic;
31.     texture->format = format;
32.     texture->access = access;
33.     texture->w = w;
34.     texture->h = h;
35.     texture->r = 255;
36.     texture->g = 255;
37.     texture->b = 255;
38.     texture->a = 255;
39.     texture->renderer = renderer;
40.     texture->next = renderer->textures;
41.     if (renderer->textures) {
42.         renderer->textures->prev = texture;
43.     }
44.     renderer->textures = texture;
45.
46.
47.     if (IsSupportedFormat(renderer, format)) {
48.         if (renderer->CreateTexture(renderer, texture) < 0) {
49.             SDL_DestroyTexture(texture);
50.             return 0;
51.         }
52.     } else {
53.         texture->native = SDL_CreateTexture(renderer,
54.                                             GetClosestSupportedFormat(renderer, format),
55.                                             access, w, h);
56.         if (!texture->native) {
57.             SDL_DestroyTexture(texture);
58.             return NULL;
59.         }
60.
61.
62.         /* Swap textures to have texture before texture->native in the list */
63.         texture->native->next = texture->next;
64.         if (texture->native->next) {
```

```

65.         texture->native->next->prev = texture->native;
66.     }
67.     texture->prev = texture->native->prev;
68.     if (texture->prev) {
69.         texture->prev->next = texture;
70.     }
71.     texture->native->prev = texture;
72.     texture->next = texture->native;
73.     renderer->textures = texture;
74.
75.
76.     if (SDL_ISPIXELFORMAT_FOURCC(texture->format)) {
77.         texture->yuv = SDL_SW_CreateYUVTexture(format, w, h);
78.         if (!texture->yuv) {
79.             SDL_DestroyTexture(texture);
80.             return NULL;
81.         }
82.     } else if (access == SDL_TEXTUREACCESS_STREAMING) {
83.         /* The pitch is 4 byte aligned */
84.         texture->pitch = (((w * SDL_BYTESPERPIXEL(format)) + 3) & ~3);
85.         texture->pixels = SDL_calloc(1, texture->pitch * h);
86.         if (!texture->pixels) {
87.             SDL_DestroyTexture(texture);
88.             return NULL;
89.         }
90.     }
91. }
92. return texture;
93. }

```

从源代码中可以看出，SDL_CreateTexture()的大致流程如下。

1. **检查输入参数的合理性。** 例如像素格式是否支持，宽和高是否小于等于0等等。
2. **新建一个SDL_Texture。** 调用SDL_calloc()（实际上就是calloc()）为新建的SDL_Texture分配内存。
3. **调用SDL_Renderer的CreateTexture()方法创建纹理。** 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CreateTexture()的方法。

1. Direct3D

Direct3D 渲染器中对应CreateTexture()的函数是D3D_CreateTexture()，它的源代码如下所示（位于render\direct3d\SDL_render_d3d.c）。

```

1. static int D3D_CreateTexture(SDL_Renderer * renderer, SDL_Texture * texture)
2. {
3.     D3D_RenderData *renderdata = (D3D_RenderData *) renderer->driverdata;
4.     D3D_TextureData *data;
5.     D3DPPOOL pool;
6.     DWORD usage;
7.     HRESULT result;
8.
9.
10.    data = (D3D_TextureData *) SDL_calloc(1, sizeof(*data));
11.    if (!data) {
12.        return SDL_OutOfMemory();
13.    }
14.    data->scaleMode = GetScaleQuality();
15.
16.
17.    texture->driverdata = data;
18.
19.
20.    #ifdef USE_DYNAMIC_TEXTURE
21.        if (texture->access == SDL_TEXTUREACCESS_STREAMING) {
22.            pool = D3DPPOOL_DEFAULT;
23.            usage = D3DUSAGE_DYNAMIC;
24.        } else
25.    #endif
26.        if (texture->access == SDL_TEXTUREACCESS_TARGET) {
27.            /* D3DPPOOL_MANAGED does not work with D3DUSAGE_RENDERTARGET */
28.            pool = D3DPPOOL_DEFAULT;
29.            usage = D3DUSAGE_RENDERTARGET;
30.        } else {
31.            pool = D3DPPOOL_MANAGED;
32.            usage = 0;
33.        }
34.
35.
36.    result =
37.        IDirect3DDevice9_CreateTexture(renderdata->device, texture->w,
38.                                       texture->h, 1, usage,
39.                                       PixelFormatToD3DFMT(texture->format),
40.                                       pool, &data->texture, NULL);
41.    if (FAILED(result)) {
42.        return D3D_SetError("CreateTexture()", result);
43.    }
44.
45.
46.    if (texture->format == SDL_PIXELFORMAT_YV12 ||
47.        texture->format == SDL_PIXELFORMAT_IYUV) {
48.        data->yuv = SDL_TRUE;
49.
50.
51.        result =
52.            IDirect3DDevice9_CreateTexture(renderdata->device, texture->w / 2,
53.                                           texture->h / 2, 1, usage,
54.                                           PixelFormatToD3DFMT(texture->format),
55.                                           pool, &data->utexture, NULL);
56.        if (FAILED(result)) {
57.            return D3D_SetError("CreateTexture()", result);
58.        }
59.
60.
61.        result =
62.            IDirect3DDevice9_CreateTexture(renderdata->device, texture->w / 2,
63.                                           texture->h / 2, 1, usage,
64.                                           PixelFormatToD3DFMT(texture->format),
65.                                           pool, &data->vtexture, NULL);
66.        if (FAILED(result)) {
67.            return D3D_SetError("CreateTexture()", result);
68.        }
69.    }
70.
71.
72.    return 0;
73. }

```

从代码中可以看出，该函数调用了Direct3D的API函数IDirect3DDevice9_CreateTexture()创建了一个纹理。

2.

OpenGL

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

```

1. static int GL_CreateTexture(SDL_Renderer * renderer, SDL_Texture * texture)
2. {
3.     GL_RenderData *renderdata = (GL_RenderData *) renderer->driverdata;

```

```

4.     GL_TextureData *data;
5.     GLint internalFormat;
6.     GLenum format, type;
7.     int texture_w, texture_h;
8.     GLenum scaleMode;
9.
10.
11.     GL_ActivateRenderer(renderer);
12.
13.
14.     if (!convert_format(renderdata, texture->format, &internalFormat,
15.                         &format, &type)) {
16.         return SDL_SetError("Texture format %s not supported by OpenGL",
17.                             SDL_GetPixelFormatName(texture->format));
18.     }
19.
20.
21.     data = (GL_TextureData *) SDL_calloc(1, sizeof(*data));
22.     if (!data) {
23.         return SDL_OutOfMemory();
24.     }
25.
26.
27.     if (texture->access == SDL_TEXTUREACCESS_STREAMING) {
28.         size_t size;
29.         data->pitch = texture->w * SDL_BYTESPERPIXEL(texture->format);
30.         size = texture->h * data->pitch;
31.         if (texture->format == SDL_PIXELFORMAT_YV12 ||
32.             texture->format == SDL_PIXELFORMAT_IYUV) {
33.             /* Need to add size for the U and V planes */
34.             size += (2 * (texture->h * data->pitch) / 4);
35.         }
36.         data->pixels = SDL_calloc(1, size);
37.         if (!data->pixels) {
38.             SDL_free(data);
39.             return SDL_OutOfMemory();
40.         }
41.     }
42.
43.
44.     if (texture->access == SDL_TEXTUREACCESS_TARGET) {
45.         data->fbo = GL_GetFBO(renderdata, texture->w, texture->h);
46.     } else {
47.         data->fbo = NULL;
48.     }
49.
50.
51.     GL_CheckError("", renderer);
52.     renderdata->glGenTextures(1, &data->texture);
53.     if (GL_CheckError("glGenTextures()", renderer) < 0) {
54.         SDL_free(data);
55.         return -1;
56.     }
57.     texture->driverdata = data;
58.
59.
60.     if ((renderdata->GL_ARB_texture_rectangle_supported)
61.         /* && texture->access != SDL_TEXTUREACCESS_TARGET */) {
62.         data->type = GL_TEXTURE_RECTANGLE_ARB;
63.         texture_w = texture->w;
64.         texture_h = texture->h;
65.         data->texw = (GLfloat) texture_w;
66.         data->texh = (GLfloat) texture_h;
67.     } else {
68.         data->type = GL_TEXTURE_2D;
69.         texture_w = power_of_2(texture->w);
70.         texture_h = power_of_2(texture->h);
71.         data->texw = (GLfloat) (texture->w) / texture_w;
72.         data->texh = (GLfloat) texture->h / texture_h;
73.     }
74.
75.
76.     data->format = format;
77.     data->formattype = type;
78.     scaleMode = GetScaleQuality();
79.     renderdata->glEnable(data->type);
80.     renderdata->glBindTexture(data->type, data->texture);
81.     renderdata->glTexParameterf(data->type, GL_TEXTURE_MIN_FILTER, scaleMode);
82.     renderdata->glTexParameterf(data->type, GL_TEXTURE_MAG_FILTER, scaleMode);
83.     /* According to the spec, CLAMP_TO_EDGE is the default for TEXTURE_RECTANGLE
84.      * and setting it causes an INVALID_ENUM error in the latest Nvidia drivers.
85.     */
86.     if (data->type != GL_TEXTURE_RECTANGLE_ARB) {
87.         renderdata->glTexParameteri(data->type, GL_TEXTURE_WRAP_S,
88.                                     GL_CLAMP_TO_EDGE);
89.         renderdata->glTexParameteri(data->type, GL_TEXTURE_WRAP_T,
90.                                     GL_CLAMP_TO_EDGE);
91.     }
92. #ifdef __MACOSX__
93. #ifndef GL_TEXTURE_STORAGE_HINT_APPLE
94. #define GL_TEXTURE_STORAGE_HINT_APPLE 0x85BC
95. #endif

```

```

95. #endif
96. #ifndef STORAGE_CACHED_APPLE
97. #define STORAGE_CACHED_APPLE 0x85BE
98. #endif
99. #ifndef STORAGE_SHARED_APPLE
100. #define STORAGE_SHARED_APPLE 0x85BF
101. #endif
102. if (texture->access == SDL_TEXTUREACCESS_STREAMING) {
103.     renderdata->glTexParameteri(data->type, GL_TEXTURE_STORAGE_HINT_APPLE,
104.                                 GL_STORAGE_SHARED_APPLE);
105. } else {
106.     renderdata->glTexParameteri(data->type, GL_TEXTURE_STORAGE_HINT_APPLE,
107.                                 GL_STORAGE_CACHED_APPLE);
108. }
109. if (texture->access == SDL_TEXTUREACCESS_STREAMING
110.     && texture->format == SDL_PIXELFORMAT_ARGB8888
111.     && (texture->w % 8) == 0) {
112.     renderdata->glPixelStorei(GL_UNPACK_CLIENT_STORAGE_APPLE, GL_TRUE);
113.     renderdata->glPixelStorei(GL_UNPACK_ALIGNMENT, 1);
114.     renderdata->glPixelStorei(GL_UNPACK_ROW_LENGTH,
115.                               (data->pitch / SDL_BYTESPERPIXEL(texture->format)));
116.     renderdata->glTexImage2D(data->type, 0, internalFormat, texture_w,
117.                              texture_h, 0, format, type, data->pixels);
118.     renderdata->glPixelStorei(GL_UNPACK_CLIENT_STORAGE_APPLE, GL_FALSE);
119. }
120. else
121. #endif
122. {
123.     renderdata->glTexImage2D(data->type, 0, internalFormat, texture_w,
124.                              texture_h, 0, format, type, NULL);
125. }
126. renderdata->glDisable(data->type);
127. if (GL_CheckError("glTexImage2D()", renderer) < 0) {
128.     return -1;
129. }
130.
131.
132. if (texture->format == SDL_PIXELFORMAT_YV12 ||
133.     texture->format == SDL_PIXELFORMAT_IYUV) {
134.     data->yuv = SDL_TRUE;
135.
136.
137.     renderdata->glGenTextures(1, &data->utexture);
138.     renderdata->glGenTextures(1, &data->vtexture);
139.     renderdata->glEnable(data->type);
140.
141.
142.     renderdata->glBindTexture(data->type, data->utexture);
143.     renderdata->glTexParameteri(data->type, GL_TEXTURE_MIN_FILTER,
144.                                 scaleMode);
145.     renderdata->glTexParameteri(data->type, GL_TEXTURE_MAG_FILTER,
146.                                 scaleMode);
147.     renderdata->glTexParameteri(data->type, GL_TEXTURE_WRAP_S,
148.                                 GL_CLAMP_TO_EDGE);
149.     renderdata->glTexParameteri(data->type, GL_TEXTURE_WRAP_T,
150.                                 GL_CLAMP_TO_EDGE);
151.     renderdata->glTexImage2D(data->type, 0, internalFormat, texture_w/2,
152.                              texture_h/2, 0, format, type, NULL);
153.
154.
155.     renderdata->glBindTexture(data->type, data->vtexture);
156.     renderdata->glTexParameteri(data->type, GL_TEXTURE_MIN_FILTER,
157.                                 scaleMode);
158.     renderdata->glTexParameteri(data->type, GL_TEXTURE_MAG_FILTER,
159.                                 scaleMode);
160.     renderdata->glTexParameteri(data->type, GL_TEXTURE_WRAP_S,
161.                                 GL_CLAMP_TO_EDGE);
162.     renderdata->glTexParameteri(data->type, GL_TEXTURE_WRAP_T,
163.                                 GL_CLAMP_TO_EDGE);
164.     renderdata->glTexImage2D(data->type, 0, internalFormat, texture_w/2,
165.                              texture_h/2, 0, format, type, NULL);
166.
167.
168.     renderdata->glDisable(data->type);
169. }
170.
171.
172. return GL_CheckError("", renderer);
173. }



```

从代码中可以看出，该函数调用了OpenGL的API函数glGenTextures(), glBindTexture()创建了一个纹理。并且使用glTexParameteri()设置了有关的一些参数。在这里有一点需要注意，在OpenGL渲染器中，如果输入像素格式是YV12或者IYUV，就会使用3个纹理。

3.

Software

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

```
[cpp]    
1. static int SW_CreateTexture(SDL_Renderer * renderer, SDL_Texture * texture)  
2. {  
3.     int bpp;  
4.     Uint32 Rmask, Gmask, Bmask, Amask;  
5.  
6.  
7.     if (!SDL_PixelFormatEnumToMasks  
8.         (texture->format, &bpp, &Rmask, &Gmask, &Bmask, &Amask)) {  
9.         return SDL_SetError("Unknown texture format");  
10.    }  
11.  
12.  
13.    texture->driverdata =  
14.        SDL_CreateRGBSurface(0, texture->w, texture->h, bpp, Rmask, Gmask,  
15.                               Bmask, Amask);  
16.    SDL_SetSurfaceColorMod(texture->driverdata, texture->r, texture->g,  
17.                           texture->b);  
18.    SDL_SetSurfaceAlphaMod(texture->driverdata, texture->a);  
19.    SDL_SetSurfaceBlendMode(texture->driverdata, texture->blendMode);  
20.  
21.  
22.    if (texture->access == SDL_TEXTUREACCESS_STATIC) {  
23.        SDL_SetSurfaceRLE(texture->driverdata, 1);  
24.    }  
25.  
26.  
27.    if (!texture->driverdata) {  
28.        return -1;  
29.    }  
30.    return 0;  
31. }
```

该函数的源代码还没有详细分析。可以看出其中调用了SDL_CreateRGBSurface()创建了“Surface”。

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我的邮箱:liushidc@163.com