

Raytracing en GPU

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Rasterization vs Raytracing:

Imágenes

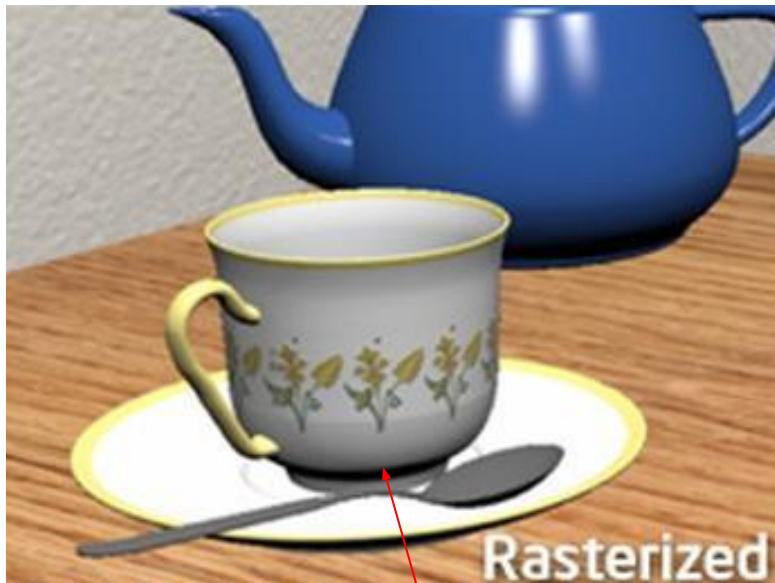


Rasterization vs Raytracing:

Materiales opacos

Imágenes

Reflección



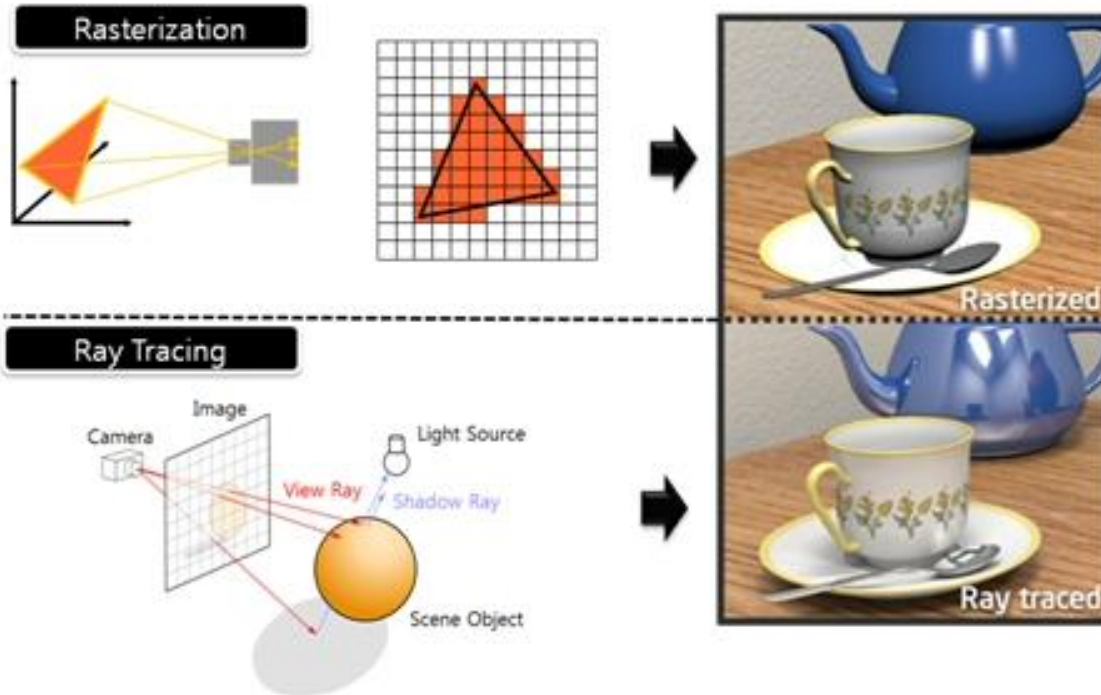
Sombra no natural



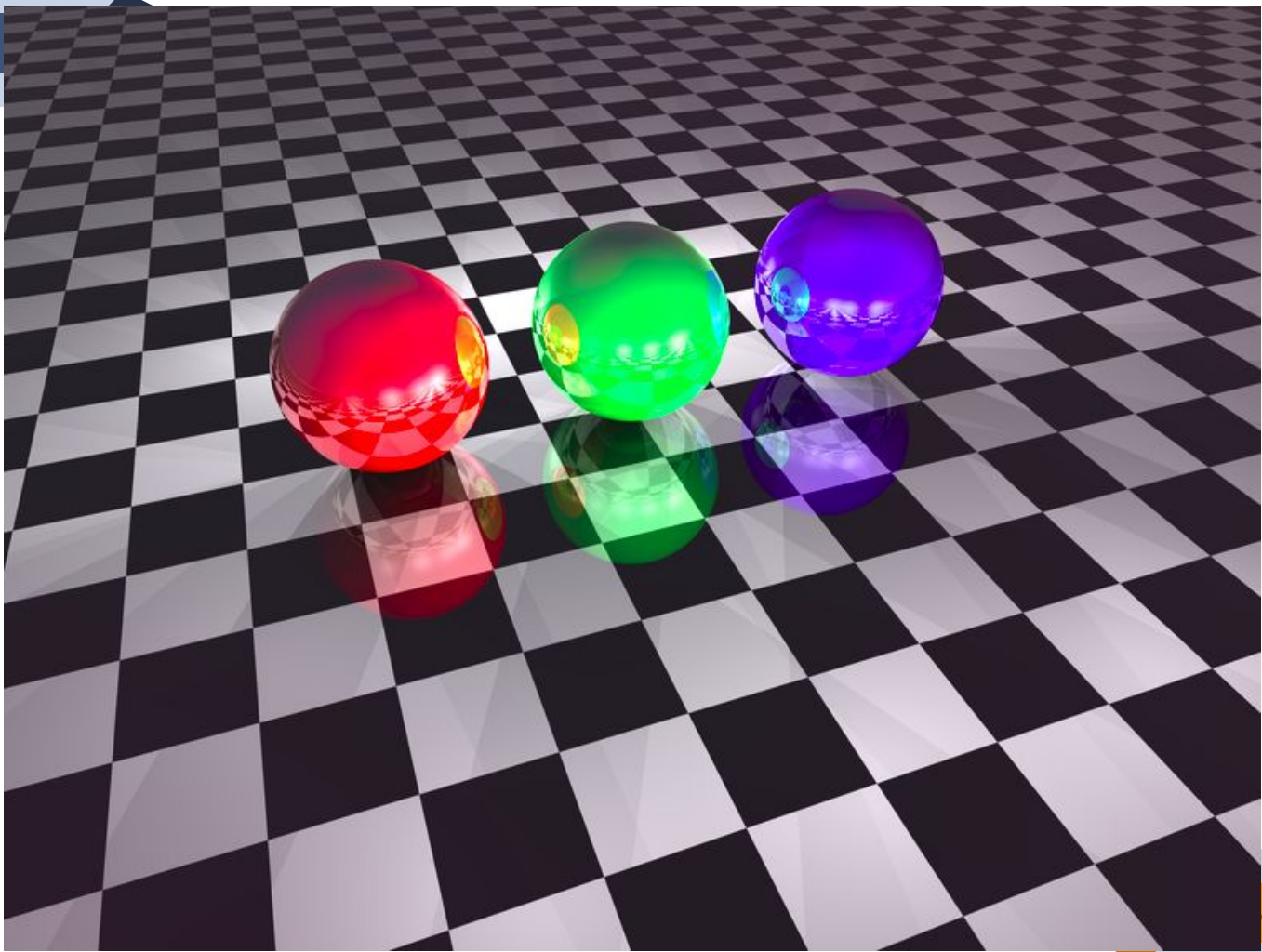
Sombra realista

Rasterization vs Raytracing:

Funcionamiento











OpenGL® ES ray tracing

PowerVR
by Imagination

CPU:

Modelo en C++

Class:

- Camera
- Ray
- Object
- Material
- Light

Light:

- Punctual
- Directional
- Spotlight
- Ambient

Material:

- Lambert
- Phong
- Reflective
- Dielectric
- Texture

Object:

- Sphere
- Mesh

De CPU a GPU: *Adapter Pattern*

class Sphere



class SphereGPUAdapter



struct DSphere



1) Inicializar DSphere en host en base a Sphere.



2) Inicializar DSphere en device en base DSphere en host (cudaMemcpy).

3) Liberar memoria en device al terminar.

```
842
843 SphereGPUAdapter::SphereGPUAdapter(Sphere *s) {
844     // Init GPU point & associated pointers
845
846     int nMats = s->getMaterials().size();
847     h_s = (DSphere*)malloc(sizeof(DSphere));
848     for (int i=0; i<3; i++) h_s->c[i] = s->getCenter()[i];
849     h_s->r = s->getRadius();
850     h_s->nMats = nMats;
851
852     cudaMalloc((void **)&d_s, sizeof(DSphere));
853     cudaMalloc((void **)&d_mats, nMats*sizeof(DMaterial*));
854     htd_mats = (DMaterial**)malloc(nMats*sizeof(DMaterial*));
855     for (int i=0; i<nMats; i++)
856         htd_mats[i] = s->getMaterials()[i]->buildDMaterial();
857
858
859     // Copy host pointers to GPU
860
861     cudaMemcpy(d_s, h_s, sizeof(DSphere),
862               cudaMemcpyHostToDevice);
863     cudaMemcpy(d_mats, htd_mats, nMats*sizeof(DMaterial*),
864               cudaMemcpyHostToDevice);
865     iniMats<<<1,1>>>(d_s, d_mats);
866 }
867
868
```

De CPU a GPU:

Memoria y recursión

**No utilizar memoria dinámica
dentro del algoritmo !!**



- 1) 10x SpeedUp
- 2) Arreglos con tamaño fijo

**No usar recursión !!
(al reflejar o refractar rayos)**



- 1) Utilizar stacks
- 2) (Tamaño máximo fijo)


```
388
389 __device__ void intersectRay(DStack *stack, DRay *ray,
390     DSpheres *sphs, DCamera *cam, const DLights *ls) {
391
392     for (int is=0; is<sphs->nSpheres; is++)
393         intersectSphere(sphs->s[is],sphs,ray,cam);
394
395     if (ray->s) {
396         for (int im=0; im<ray->s->nMats; im++) {
397             colorate(stack,ray->s->mats[im],sphs,ls,cam,ray);
398         }
399     } else copyVec(ray->col, cam->bg_col);
400 }
401
402
```



Demo

De CPU a GPU:

Resultados

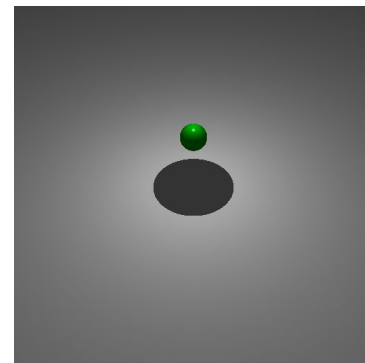


Imagen	CPU (s)	GPU (s)	SpeedUp
128x128	0.25	0.0004	625
256x256	0.91	0.0007	1300
512x512	4.43	0.0021	2109

De CPU a GPU:

Resultados

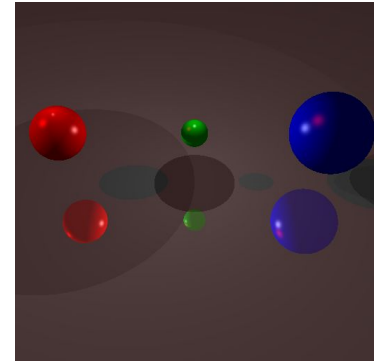


Imagen	CPU (s)	GPU (s)	SpeedUp
128x128	0.68	0.0006	1133
256x256	2.63	0.0014	1879
512x512	10.45	0.0046	2271

De CPU a GPU:

Resultados

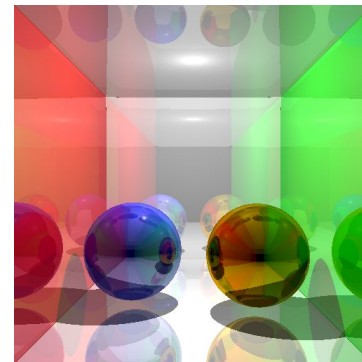


Imagen	CPU (s)	GPU (s)	SpeedUp
128x128	2.00	0.0010	2000
256x256	8.01	0.0029	2762
512x512	32.59	0.0098	3326



Demo

```

10
11 unsigned char* getMappedBuffer(unsigned short width,
12 unsigned short height) {
13
14     glfwInit();
15     window = glfwCreateWindow(width, height, "Window", NULL, NULL);
16     glfwMakeContextCurrent(window);
17     glewExperimental = GL_TRUE; glewInit();
18
19     glGenBuffers(1, &gl_pixelBufferID);
20     glBindBuffer(GL_PIXEL_UNPACK_BUFFER, gl_pixelBufferID);
21     glBufferData(GL_PIXEL_UNPACK_BUFFER, width*height*4, NULL,
22         GL_DYNAMIC_COPY);
23
24     glEnable(GL_TEXTURE_2D);
25     glGenBuffers(1, &gl_textureID);
26     glBindTexture(GL_TEXTURE_2D, gl_textureID);
27     glTexParameteri(GL_TEXTURE_2D,
28         GL_TEXTURE_MAG_FILTER, GL_NEAREST);
29     glTexParameteri(GL_TEXTURE_2D,
30         GL_TEXTURE_MIN_FILTER, GL_NEAREST);
31     glTexParameteri(GL_TEXTURE_2D,
32         GL_TEXTURE_WRAP_S, GL_CLAMP_TO_EDGE);
33     glTexParameteri(GL_TEXTURE_2D,
34         GL_TEXTURE_WRAP_T, GL_CLAMP_TO_EDGE);
35     glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA8, width, height, 0,
36         GL_RGBA, GL_UNSIGNED_BYTE, NULL);
37
38     cudaGLRegisterBufferObject(gl_pixelBufferID);
39     unsigned char *d_textureBufferData;
40     cudaGLMapBufferObject((void**)&d_textureBufferData,
41         gl_pixelBufferID);
42     return d_textureBufferData;
43 }
44

```

```

44
45 void write_image(unsigned short width, unsigned short height){
46
47     glTexSubImage2D(GL_TEXTURE_2D, 0,0,0, width, height,
48         GL_RGBA, GL_UNSIGNED_BYTE, NULL);
49
50     glClear(GL_COLOR_BUFFER_BIT);
51     glBegin(GL_QUADS);
52         glTexCoord2f(0.0, 0.0);
53         glVertex2f(-1.0, -1.0);
54         glTexCoord2f(0.0, 1.0);
55         glVertex2f(-1.0, 1.0);
56         glTexCoord2f(1.0, 1.0);
57         glVertex2f( 1.0, 1.0);
58         glTexCoord2f(1.0, 0.0);
59         glVertex2f( 1.0, -1.0);
60     glEnd();
61
62     do {
63         glfwSwapBuffers(window);
64         glfwPollEvents();
65     } while (glfwGetKey(window, GLFW_KEY_ESCAPE) != GLFW_PRESS &&
66         glfwWindowShouldClose(window) == 0);
67
68     cudaGLUnregisterBufferObject(gl_pixelBufferID);
69     cudaGLUnmapBufferObject(gl_pixelBufferID);
70     glDeleteBuffers(1, &gl_pixelBufferID);
71     glDeleteTextures(1, &gl_textureID);
72     glfwTerminate();
73
74

```


De CPU a GPU:

OctTree

class OctTree



class OctTreeGPUAdapter



struct DOctTree

**No usar recursión !!
(al profundizar en el árbol)**



- 1) Utilizar stack para nodos
- 2) (Tamaño máximo fijo)

```

328
329 __device__ void intersectRay(DRay *ray, DSpheres *sphs,
330     DCamera *cam) {
331
332     DOctTree oct_s[20], *oct; DOctStack *octStack, octStack_s;
333     octStack = &octStack_s; int child;
334     for (int i=0; i<20; i++) octStack->oct[i] = &oct_s[i];
335     initOctStack(octStack);
336     if (ray->oct) {
337         octStackPush(octStack, ray->oct, 0);
338     }
339
340     while (octStack->size) {
341
342         child = topChild(octStack);
343         oct = octStackPop(octStack);
344         if (oct->type == LEAVE) {
345             intersectChildren(oct, ray, cam);
346         } else if (child < 8) {
347             octStackPush(octStack, oct, child+1);
348             intersectOctNode(oct->child[child], ray, cam, octStack);
349         } else continue;
350     }
351
352     for (int is=0; is<sphs->nSpheres; is++)
353         intersectSphere(sphs->s[is], sphs, ray, cam);
354 }
355

```

De CPU a GPU:

Resultados

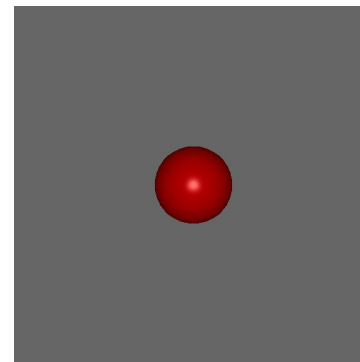


Imagen	CPU (s)	GPU (s)	SpeedUp
128x128	14.80	0.63	23.49
256x256	59.42	1.83	32.47
512x512	233.65	6.45	36.22

Construcción OctTree: 1.13 seg

De CPU a GPU:

Resultados

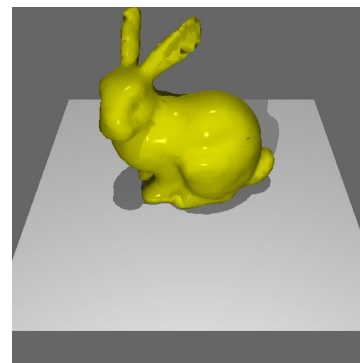


Imagen	CPU (s)	GPU (s)	SpeedUp
128x128	26.22	1.57	16.70
256x256	106.76	4.58	23.31
512x512	427.20	17.87	23.91

Construcción OctTree: 4.57 seg

De CPU a GPU:

Resultados

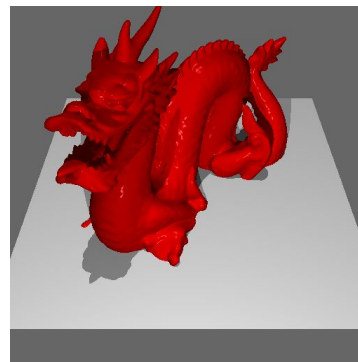


Imagen	CPU (s)	GPU (s)	SpeedUp
128x128	68.95	5.84	11.81
256x256	273.72	16.44	16.65
512x512	1159.60	54.31	21.35

Construcción OctTree: 189.44 seg

Conclusiones:

Comentarios

- 1) Muy buena interacción entre CUDA y OpenGL
- 2) Printf, kernel único y cuda-gdb (PREEMPTIVE)
- 3) Probar texturas y hacer profiling para el OctTree
- 4) Provar con varias GPUs

⋮

Referencias

- 1) Técnicas Avanzadas de Rendering:
- 2) What Every CUDA Programmer Should Know About OpenGL:
http://www.nvidia.com/content/gtc/documents/1055_gtc09.pdf
- 3) CC7615Malloc in CUDA kernel? <https://stackoverflow.com/questions/9806299/>
- 4) Best way of traversing an OctTree in CUDA:
<https://devtalk.nvidia.com/default/topic/409587/>