6.189 IAP 2007

Student Project Presentation

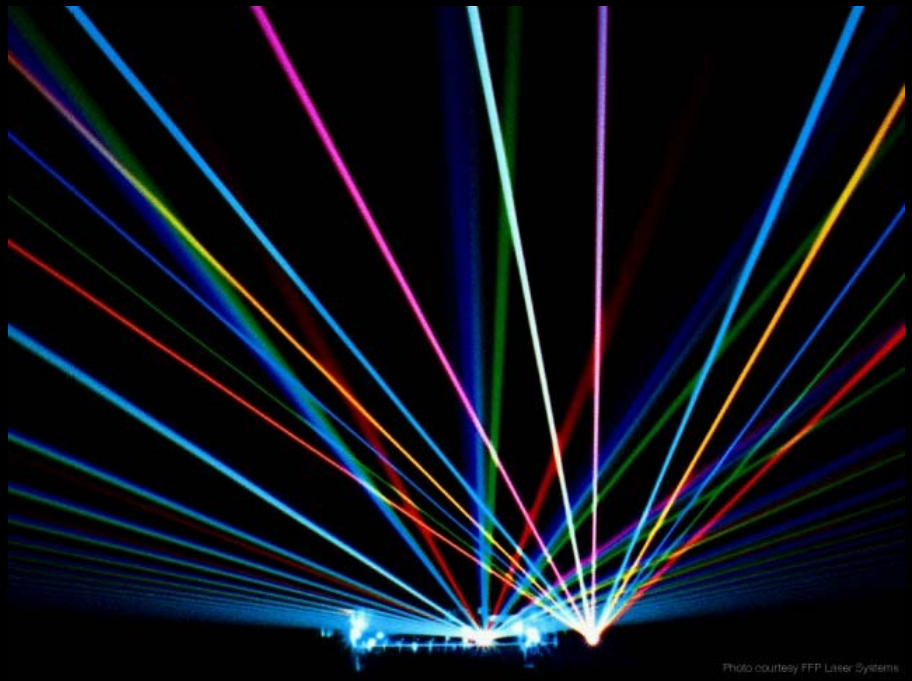
Blue-Steel Ray Tracer


blue-steel

distributed

real-time

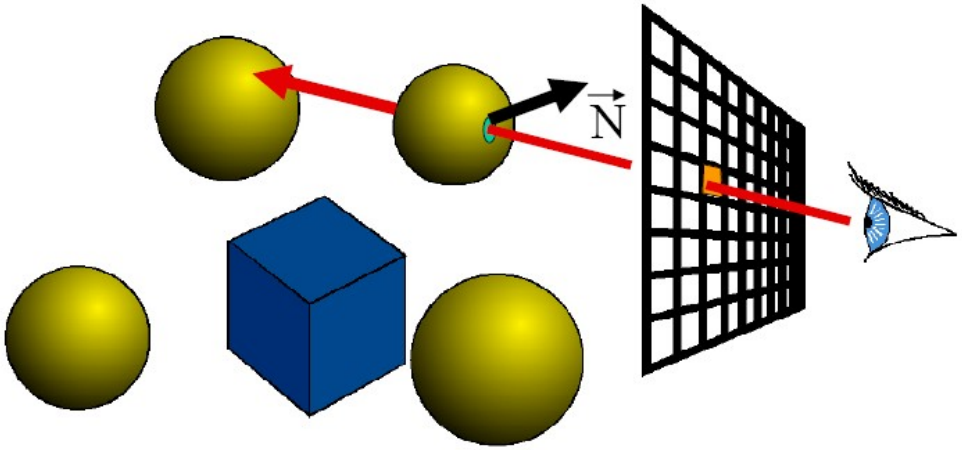
ray tracer



blue-steel

Ray Casting

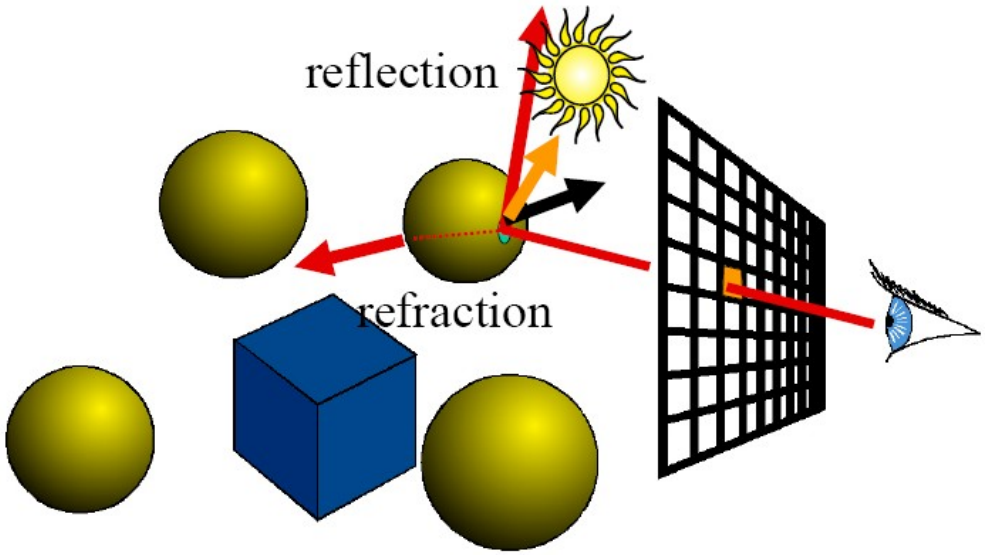
```
For every pixel
   Construct a ray from the eye
   For every object in the scene
       Find intersection with the ray
       Keep if closest
    Shade depending on light and normal vector
```



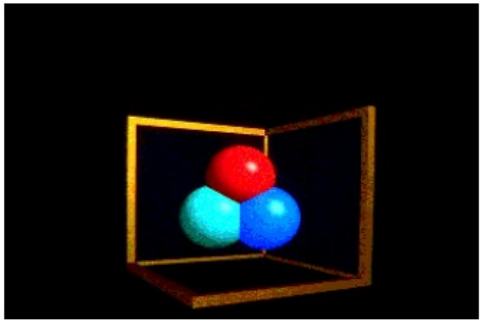
Finding the intersection and normal is the central part of ray casting

Ray Tracing

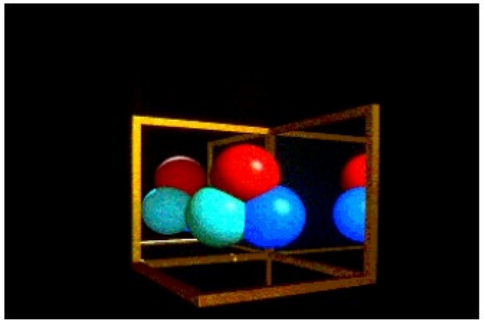
- Secondary rays (shadows, reflection, refraction)



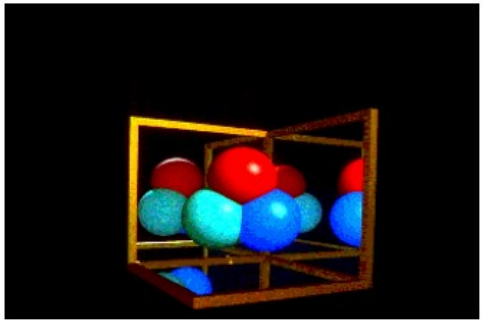
Recursion For Reflection



0 recursion



1 recursion



2 recursions

Resolution

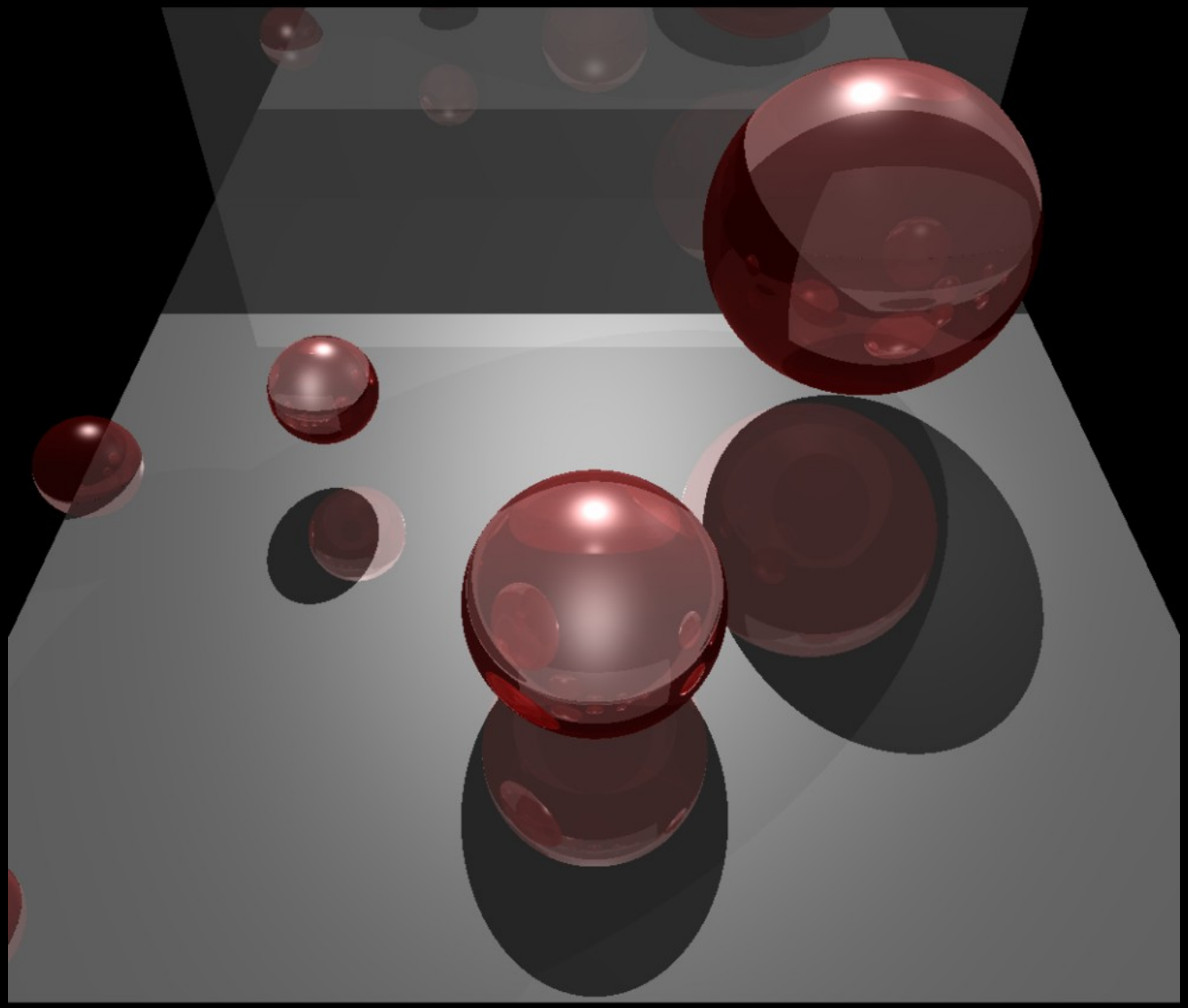
1024x1024

Recursion depth

100

Rendering time

2.6 seconds



blue-steel

optimization

SIMD SIMD SIMD SIMD

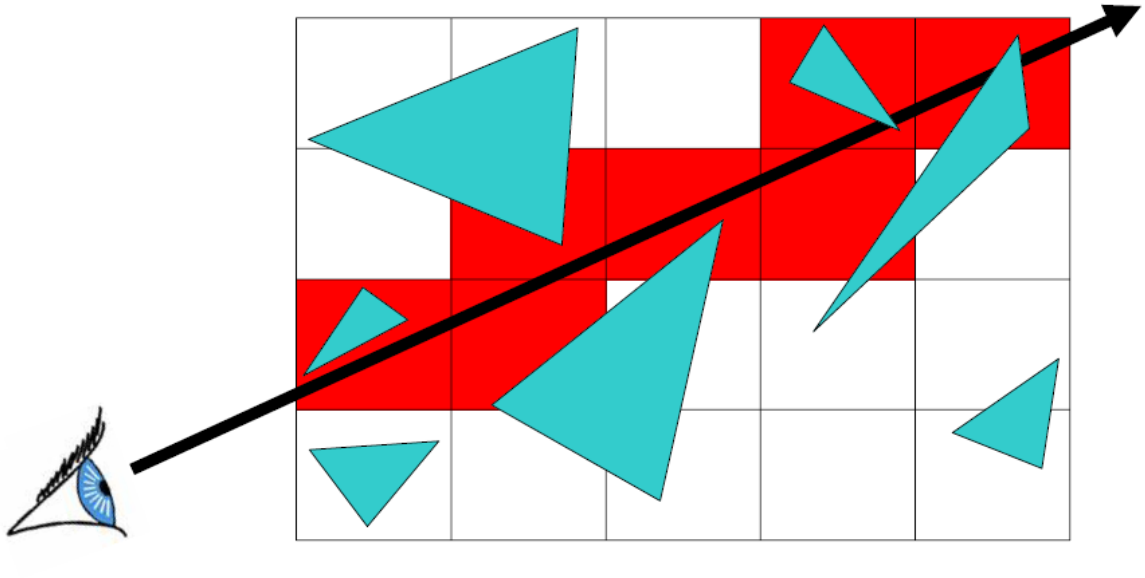
pipelining

no inheritence in rendering

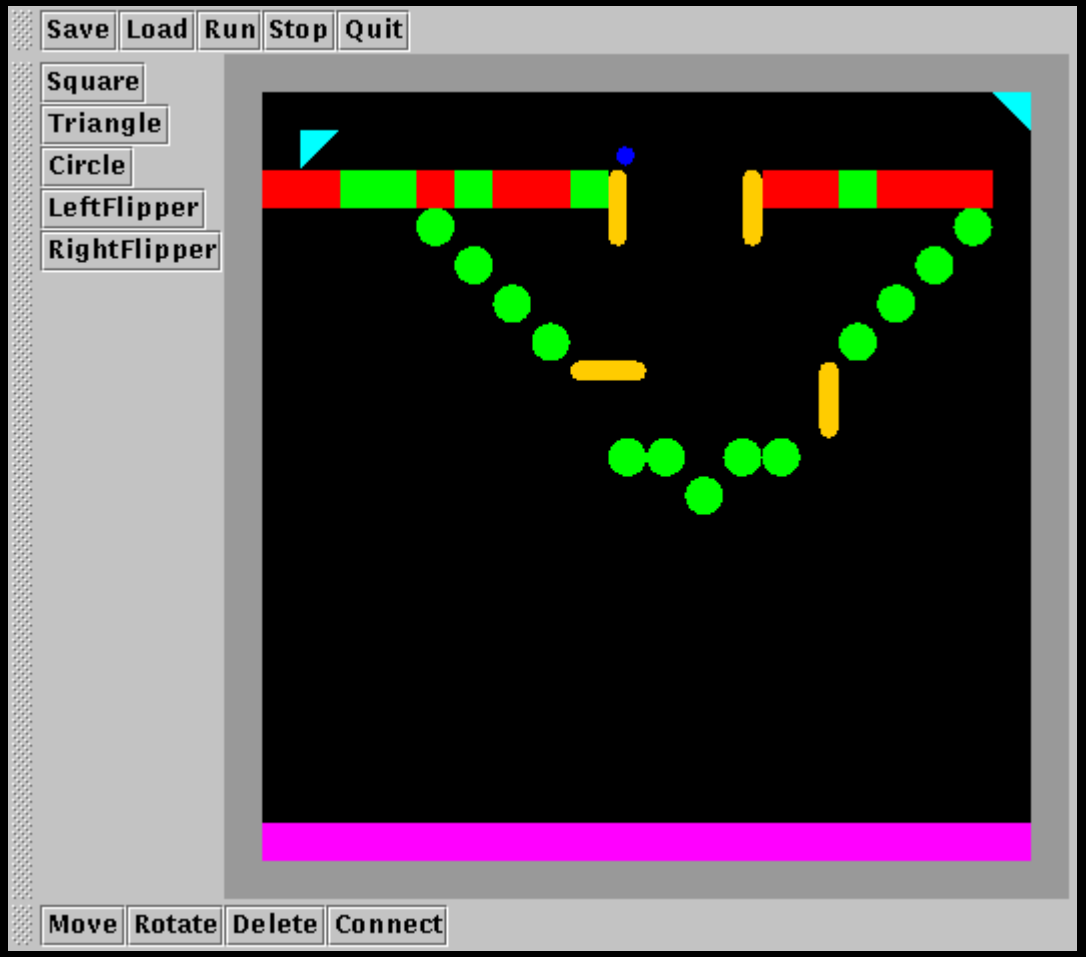
```
void Box :: intersectPacket(const RayPacket &r, HitPacket &h, float tmin) {

  //vector float epsilon = spu_splats(0.0001f);
  vector float zero = spu_splats(0.0f);
  vector float max_v = spu_splats(MAX_FLOAT);

  vector float tmin_v = spu_splats(tmin);

  vector unsigned char splat_word_0 =
    (vector unsigned char){0, 1, 2, 3, 0, 1, 2, 3, 0, 1, 2, 3, 0, 1, 2, 3};
  vector unsigned char splat_word_1 =
    (vector unsigned char){4, 5, 6, 7, 4, 5, 6, 7, 4, 5, 6, 7, 4, 5, 6, 7};
  vector unsigned char splat_word_2 =
    (vector unsigned char){8, 9,10,11, 8, 9,10,11, 8, 9,10,11, 8, 9,10,11};

  vector float minx = spu_shuffle(m_min, m_min, splat_word_0);
  vector float maxx = spu_shuffle(m_max, m_max, splat_word_0);
  vector float miny = spu_shuffle(m_min, m_min, splat_word_1);
  vector float maxy = spu_shuffle(m_max, m_max, splat_word_1);
  vector float minz = spu_shuffle(m_min, m_min, splat_word_2);
  vector float maxz = spu_shuffle(m_max, m_max, splat_word_2);

  vector unsigned int rdxgt0 = spu_cmpgt(r.dx, zero);
  vector unsigned int rdygt0 = spu_cmpgt(r.dy, zero);
  vector unsigned int rdzgt0 = spu_cmpgt(r.dz, zero);

  vector float rdxre = spu_re(r.dx);
  vector float rdyre = spu_re(r.dy);
  vector float rdzre = spu_re(r.dz);

  vector float tx1 = spu_sub(minx, r.x0);
  vector float tx2 = spu_sub(maxx, r.x0);
  vector float ty1 = spu_sub(miny, r.y0);
  vector float ty2 = spu_sub(maxy, r.y0);
  vector float tz1 = spu_sub(minz, r.z0);
  vector float tz2 = spu_sub(maxz, r.z0);

  tx1 = spu_mul(tx1, rdxre);
  tx2 = spu_mul(tx2, rdxre);
  ty1 = spu_mul(ty1, rdyre);
  ty2 = spu_mul(ty2, rdyre);
  tz1 = spu_mul(tz1, rdzre);

  vector float tmn = spu_sel(tx2, tx1, rdxgt0);
  vector float tmx = spu_sel(tx1, tx2, rdxgt0);
  vector float tymn = spu_sel(ty2, ty1, rdygt0);
  vector float tymx = spu_sel(ty1, ty2, rdygt0);
```

blue-steel

Regular Grid

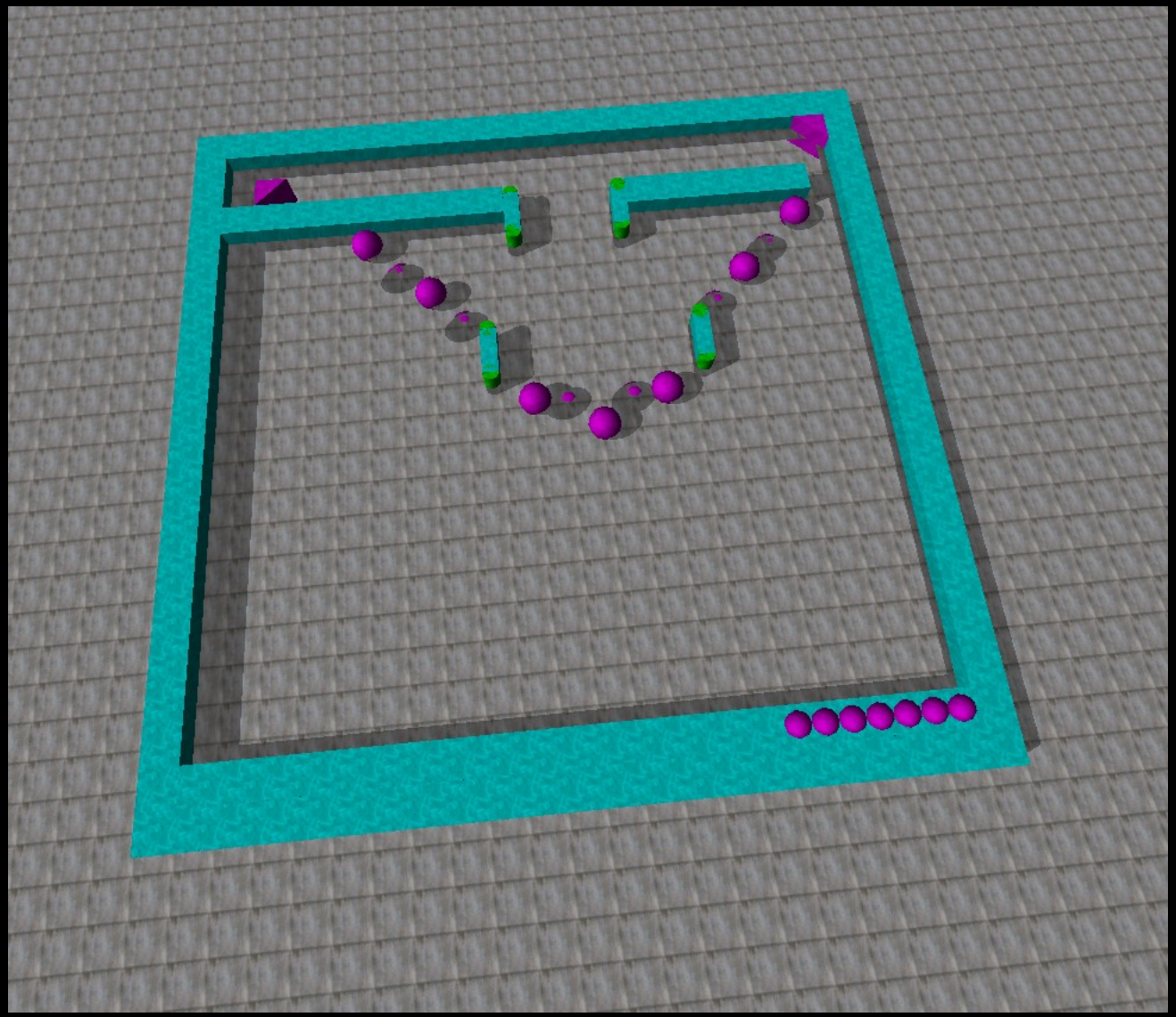


Gizmoball



blue-steel

3D physics



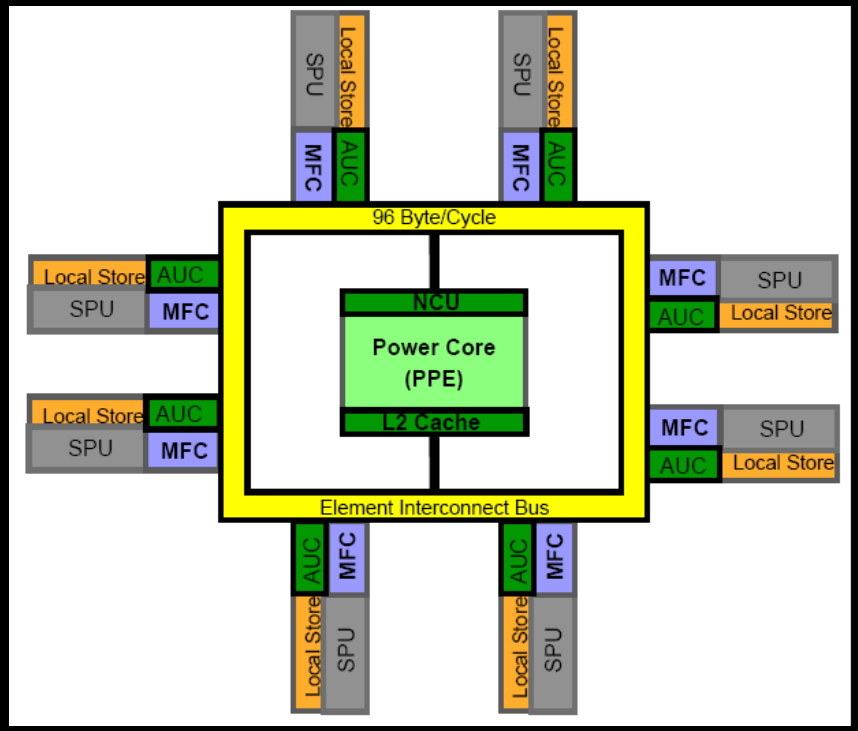
parallelization

task is intrinsically parallelizable

each spu renders every sixth line of screen

spus dma pixel data directly to frame buffer

ppu controls physics, program initiation, scene parsing



performance

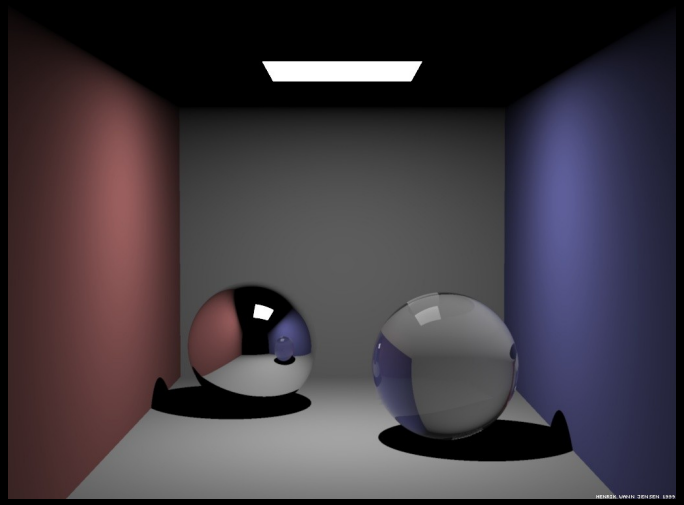
linear speedup with respect to number of cores used for rendering

measured in length of time taken to generate a given frame

final framerate with reflection, refraction, procedural shading,

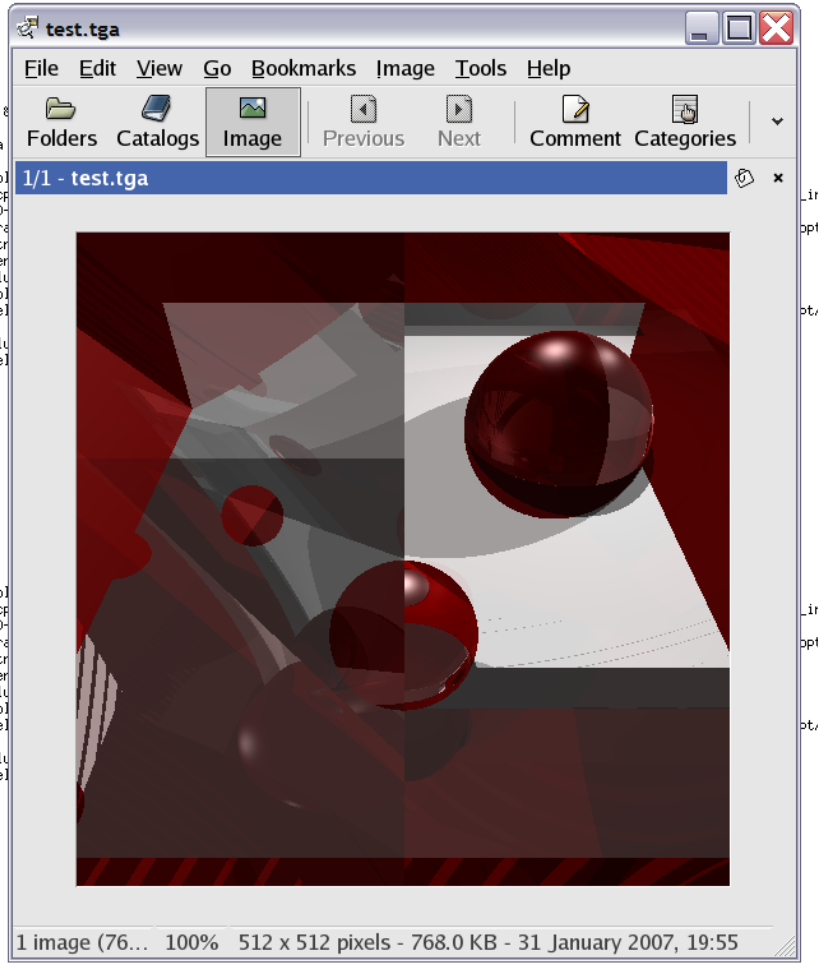
bump mapping, shadows, and blending: 10 frames per second

total rays traced: over 5,000,000 per second



blue-steel

problems




```
Camera center: 1.000000 -0.500000 1.500000
(2)Done rendering scene
(4)Done rendering scene
(5)Done rendering scene
(1)Done rendering scene
(0)Done rendering scene
(3)Done rendering scene
[natalia3@sloth blue-steel]$ gthumb test.tga &
[8] 21112
[7]   Done                    gthumb test.tga
[natalia3@sloth blue-steel]$ make
make[1]: Entering directory `/home/natalia3/bl
/opt/ibmcmp/xlc/8.1/bin/spuxlc++          -qcp
"../src/../src/hitpacket.h", line 13.12: 1540-
/opt/ibmcmp/xlc/8.1/bin/spuxlc++ -o spu_raytra
/usr/bin/embedspu -m32 spu_raytracer spu_raytr
/usr/bin/ar -qcs spu_raytracer.a spu_raytracer
make[1]: Leaving directory `/home/natalia3/blu
make[1]: Entering directory `/home/natalia3/bl
/opt/ibmcmp/xlc/8.1/bin/ppuxlc++ -o blue-steel
cp -pf blue-steel ../blue-steel
make[1]: Leaving directory `/home/natalia3/blu
[natalia3@sloth blue-steel]$ sudo ./blue-steel
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
(3)Done rendering scene
(2)Done rendering scene
(4)Done rendering scene
(5)Done rendering scene
(1)Done rendering scene
(0)Done rendering scene
[natalia3@sloth blue-steel]$ make
make[1]: Entering directory `/home/natalia3/bl
/opt/ibmcmp/xlc/8.1/bin/spuxlc++          -qcp
"../src/../src/hitpacket.h", line 13.12: 1540-
/opt/ibmcmp/xlc/8.1/bin/spuxlc++ -o spu_raytra
/usr/bin/embedspu -m32 spu_raytracer spu_raytr
/usr/bin/ar -qcs spu_raytracer.a spu_raytracer
make[1]: Leaving directory `/home/natalia3/blu
make[1]: Entering directory `/home/natalia3/bl
/opt/ibmcmp/xlc/8.1/bin/ppuxlc++ -o blue-steel
cp -pf blue-steel ../blue-steel
make[1]: Leaving directory `/home/natalia3/blu
[natalia3@sloth blue-steel]$ sudo ./blue-steel
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
Camera center: 1.000000 -0.500000 1.500000
(4)Done rendering scene
(5)Done rendering scene
(3)Done rendering scene
(2)Done rendering scene
(0)Done rendering scene
(1)Done rendering scene
[natalia3@sloth blue-steel]$ make
make[1]: Entering directory `/home/natalia3/blue-steel/spu'
/opt/ibmcmp/xlc/8.1/bin/spuxlc++          -qcpluscmt -M -ma -I. -I ../src/ -I.. -I /opt/ibm/cell-sdk/prototype//sysroot/usr/spu/include -qinclude=spu_intrinsics.h   -O3 -g  -c ../src/box.cpp
"../src/../src/hitpacket.h", line 13.12: 1540-1608 (W) An anonymous union should only define non-static data members.
/opt/ibmcmp/xlc/8.1/bin/spuxlc++ -o spu_raytracer  triangle.o spu_raytracer.o sphere.o plane.o camera.o raytracer.o light.o material.o box.o      -L/opt/ibm/cell-sdk/prototype//sysroot/usr/spu/lib -Wl,-N  -lvector -lmisc -lm
/usr/bin/embedspu -m32 spu_raytracer spu_raytracer spu_raytracer-embed.o
/usr/bin/ar -qcs spu_raytracer.a spu_raytracer-embed.o
make[1]: Leaving directory `/home/natalia3/blue-steel/spu'
make[1]: Entering directory `/home/natalia3/blue-steel/ppu'
/opt/ibmcmp/xlc/8.1/bin/ppuxlc++ -o blue-steel  main.o image.o fb.o   -L../lib/   -L/opt/ibm/cell-sdk/prototype//sysroot/usr/lib -Wl,-m,elf32ppc -R/opt/ibm/cell-sdk/prototype//sysroot/usr/lib ../spu/spu_raytracer.a -lspe -lm
cp -pf blue-steel ../blue-steel
make[1]: Leaving directory `/home/natalia3/blue-steel/ppu'
```

blue-steel

team

scott fisher

michael d'ambrosio

brian sweatt

natalia chernenko

rj ryan

leevar williams