NAME

rtrace - ray tracing program

SYNOPSIS

rtrace [options] scene image [>log]

AUTHOR

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DESCRIPTION

rtrace command performs ray tracing from a SFF text file which must describe a scene with objects, lights, surface definitions, textures, etc. This scene file must be in the appropriate format, as described bellow.
Basically, ray tracing is an algorithm for the creation of realistic images from the geometry and attributes of objects, lights, etc. This ray tracer supports several types of objects (sphere, box, bicubic patch, cone, cylinder, polygon, triangle and text), CSG and list operations, different light types, reasonable surface definitions, lots of textures, several anti-aliasing schemes, depth of field, stereoscopic image creation and so on...

OPTIONS

[wimage-width] [himage-height]
The parameters image-width and image-height define the image size. Defaults are 256x256.

[Aaliasing-threshold]
[Sshading-threshold]
[Tambient-threshold]
The parameters aliasing-threshold (pixel supersampling), shading-threshold (shading rays propagation) and ambient-threshold (ambient rays distribution caching) control the image quality (0-best, 1-poor). Defaults are 0.05, 0.01 and 0 (no ambient threshold). Good ranges are 0.1-0.03, 0.01-0.001 and 0.01-0.00001, respectively.

[aantialiasing-mode]
The parameter antialiasing-mode chooses adaptive supersampling antialiasing (0-default), semi-adaptive supersampling antialiasing (1) or normal supersampling antialiasing (2-should be used with nonzero focal apertures).

[Bmaskfile]
The parameter maskfile creates a file with a background mask, suitable for mixing images (it is like an alpha channel).

[ccluster-size]
The parameter cluster-size controls the enclosing of objects (number of grouped objects per cluster) in the object hierarchy. Use a low value for sparse scenes, a high value for dense scenes (4-default).

[dambient-levels]
The parameter ambient-levels defines the number of shading levels (shading tree depth) in which ambient lighting calculations will be done through ray distribution (0-default, ie, no ray distribution). Use low values!

[Dambient-samples]
The parameter ambient-samples defines the maximum number of distributed rays to be used in ambient lighting calculations (16-default). Again, use with care.

[iintersect-mode]
The parameter intersect-mode chooses, in adaptive supersampling antialiasing, between testing all scene objects (1) or only the objects found at the pixel corners and inside (0-default; this greatly reduces CPU time, but with very small objects, it sometimes fails).

[Iintersect-adjust-mode]
The parameter intersect-adjust-mode avoids some problems with invalid self-intersections (1) (0-default). Scenes with text objects should be traced with this parameter equal to 1.

[jjittering-mode]
The parameter jittering-mode chooses jittered sampling (1) or not (0-default). Sometimes, activating it produces better images from scenes with small tricky details.

[llighting-mode]
The parameter light-mode controls the generation of shadow rays through non-opaque objects: 0-none (default), 1-partial, 2-full. If a scene has translucent objects, to obtain realism one should use 1 or 2 (better).

[mshading-mode]
The parameter shading-mode chooses between shading models: 0-normal phong, 1-strauss (default but slower) (note: this model was developed by Paul Strauss of SGI).

[nnormal-mode]
The parameter normal-mode controls the correction of surface normals, so that it points against the incident ray: 0-always (default), 1-only inside objects. With "correct" objects, it is good to use 1.

[znormal-check-mode]
The parameter normal-check-mode controls the correction of surface normals when textures that modify the normal are used, as they may sometimes create strange surface effects. This tends to happen if the scale of the normal perturbation is big. 0-no correction (default), 1-correction.

[Rrawfile]
The parameter rawfile creates a raw image file, without any antialiasing (all defects show up!).

[psampling-levels]
The parameter sampling-levels controls the amount of sampling levels inside pixels: 0-none ... 3-maximum (default). A reasonable value is 2 for high resolutions, but for small ones 3 gives better (and slower) results.

[sshading-levels]
The parameter shading-levels establishes a maximum shading tree depth (default is 8). When a scene has transparent/reflective objects, it may be important to lower this parameter, or else the tracing never stops. In the other cases, there should be no problem allowing it to be big.

[ttexture-mode]
The parameter texture-mode allows the definition of texture(s) for the objects: 0-no textures (default), 1-with textures defined inside objects field, 2-with textures defined after objects field. As textures may consume much CPU time, they should be activated only for final images.

[vview-mode]
The parameter view-mode chooses the view mode: 0-normal (default), 1-left eye, 2-right eye.

[Pfocal-aperture]
The parameter focal-aperture defines the focal aperture of the camera (default 0.0, ie, pinhole camera). If different than zero, there is depth of field, and so adaptive super-sampling antialiasing will not work well.

[Ffocal-distance]
The parameter focal-distance defines the focal distance of the camera (default is the distance from the eye point to the look point).

[Estereo-separation]
The parameter stereo-separation controls the separation between the left and the right eye. If negative, it represents a percentage of the gaze distance.

[Ooutput-format]
The parameter output-format chooses between the PIC format (0-default) or the PPM format (1).

[Vverbose-mode]
The parameter verbose-mode supresses any messages (0) or shows listing of parameters (1), previous plus statistics (2-default) or previous plus a line by line echo of the tracing (3-default on DOS and transputers).

The scene data internal syntax (SFF) is described bellow.

The image file will contain the ray traced image. The image file has a 4 byte header composed of width LS and MS bytes, height LS and MS bytes and RGB byte triplets starting in the upper left corner line by line to the lower right corner.

RESTRICTIONS

The straightforward use:

```
rtrace demo.sff demo.pic
```

is not recommended, as ray tracing usually takes lots of CPU time to execute.

So, it is better to do:

```
rtrace demo.sff demo.pic >demo.log &
```

or then use nice (1) or similar strategies.

BUGS

No bugs known. They have to be hidden deep somewhere, as usual.

DESCRIPTION

SFF (Simple File Format) description follows. This is a very crude ASCII format, almost like if generated by a lexical analyser. The idea is to have other programs create scene descriptions in more sophisticated ways, and then feed the tokenized results to this program. So, it behaves accordingly to the UNIX philosophy: one program for one task. Complaints are not wellcome!...

There is a reasonable scene language available (SCN) that allows the creation of scenes with much more flexibility; the converter is called 'scn2sff' and works directly with this program.

Note: the ^(circunflex) character represents start of line.

```
[Start of File]
^... Comment
^Eye(X Y Z)
^Look(X Y Z)
^Up(X Y Z)
^View_angle(H V) [1,89 degrees]
^... Comment
^Background(R G B)
^Ambient(R G B)
^... Comment
^Light_type(Type) Position(X Y Z) Bright(R G B) ...
  |                                              |
  |                 /----------------------------/
  |                 |
  V                 V
 1-POINT:
 2-DIRECTIONAL: Direction(X Y Z) Angle(La) Light_Factor(Lf)
 3-EXTENDED:    Radius(R) Samples(N)
^Etc
^<NL>
^... Comment
^Surface_type(Type) Color(R G B) ...
  |                               |
  |        /----------------------/
  |        |
  V        V
 1-: Dif(R G B) Spec(R G B) Phong(Pf) Metal(Mf) Trans(R G B)
 2-: Smoothness(R G B) Metalness(R G B) Transmission(R G B)
^Etc
^<NL>
^... Comment
^Object_type(Type) Surface_ID(S) Refraction(Re) ...
  |                                              |
  |                    /-------------------------/
  |                    |
  V                    V
 1-SPHERE:          Center(X Y Z) Radius(R)
 2-PARALLELIPIPED:  Center(X Y Z) Size(X Y Z)
 3-PATCH:           Origin(X Y Z) Scale(X Y Z) Filename(...)
 4-CONE/CYLINDER:   Base(X Y Z) Base_Radius(Rb) Apex(X Y Z)
                    Apex_Radius(Ra)
 5-POLYGON:         Origin(X Y Z) Scale(X Y Z) Filename(...)
 6-TRIANGLE:        Origin(X Y Z) Scale(X Y Z) Filename(...)
 7-TEXT:            Filename(...)
or
 64-TEXTURE:        see below
 65-TRANSFORMATION: Object_ID(I)
                    Transform(X1 Y1 Z1 W1 ... X4 Y4 Z4 W4)
 66-CSG 0:          Surface_ID(S) Refraction(Re) (Union-0
```

```
Sub-1 Int-2)
    CSG 1:          Next CSG member
    CSG 2:          End of CSG
 67-LIST 0:         Surface_ID(S) Refraction(Re)
    LIST 1:         End of List
^Etc
^<NL>
^... Comment
^Texture_type(Type) Object_ID(I)
  |                 Transform(X1 Y1 Z1 W1 ... X4 Y4 Z4 W4)
  |                 ...
  |                  |
  V                  V
 0-NULL:
 1-CHECKER:   Surface_ID(S)
 2-BLOTCH:    Scale(K) Surface_ID(S) [Filename(...) or -]
 3-BUMP:      Scale(K)
 4-MARBLE:    [Filename(...) or -]
 5-FBM:       Offset(K) Scale(K) Omega(K) Lambda(L)
              Threshold(K) Octaves(O)
              [Filename(...) or -]
 6-FBMBUMP:   Offset(K) Scale(K) Lambda(L) Octaves(O)
 7-WOOD:      Color(R G B)
 8-ROUND:     Scale(K)
 9-BOZO:      Turbulence(K) [Filename(...) or -]
 10-RIPPLES:  Frequency(K) Phase(K) Scale(K)
 11-WAVES:    Frequency(K) Phase(K) Scale(K)
 12-SPOTTED:  [Filename(...) or -]
 13-DENTS:    Scale(K)
 14-AGATE:    [Filename(...) or -]
 15-WRINKLES: Scale(K)
 16-GRANITE:  [Filename(...) or -]
 17-GRADIENT: Turbulence(K) Direction(X Y Z)
              [Filename(...) or -]
 18-IMAGEMAP: Turbulence(K) Mode(K) Axis(X Y) Filename(...)
 19-GLOSS:    Scale(K)
 20-BUMP3:    Scale(K) Size(K)
^<NL>
^... Comments
[End of File]
```

1. Valid ranges of data

RGB must be in [0,1[(Note: RGB brightness of lights may be between]-300,300[; negative values mean to not attenuate with distance).

XYZ must be in [-10000,10000]

Factor must be in [0,300[

Filename must a valid filename for the operating system, or then '-', in which case data is read from the standard input or the current SFF stream.

2. Patch specification

File format for PATCH (bicubic 4-sided patch):

```
[Start]
^Patch_1_Index(1 2 3 4 5 6 7 8 9 10 11 12)
^Patch_2
^Etc
^<NL>
^Patch_Index_1_Coords(X Y Z)
^Patch_Index_2_Coords(X Y Z)
^Etc
^<NL>
^...
[End]
```

3. Polygon specification

File format for POLYGON (n-sided planar polygon):

```
[Start]
^Polygon_1_Vertex_Number Polygon_1_Index(1 2 3 ...)
^Polygon_2
^Etc
^<NL>
^Polygon_Index_1_Coords(X Y Z)
^Polygon_Index_2_Coords(X Y Z)
^Etc
^<NL>
^...
[End]
```

4. Triangle specification

File format for TRIANGLE (3-sided polygon with vertex normals):

```
[Start]
^Triangle_1_Vertice_1(X Y Z) Normal_1(X Y Z)
            Vertice_2(X Y Z) Normal_2(X Y Z)
            Vertice_3(X Y Z) Normal_3(X Y Z)
^Triangle_2
^<NL>
^...
[End]
```

5. An example

```
[Start of File]
View
25 25 7         - Eye point
0 0 0           - Look point
0 1 0           - Up vector
30 30           - View angles
Colors
0.196 0.6 0.8   - Background (Sky Blue)
0.1 0.1 0.1     - Ambient light
Lights
1 0 60 60 0.9 0.9 0.9  - Point Light 1
1 20 40 -7 0.9 0.9 0.9 - Point Light 2
<NL>
Surfaces
1 0.6 0.8 0.196 0.99 0.99 0.99 0 0 0 0 0 0 0 0
1 0.9 0.9 0.9 0.5 0.5 0.5 0.5 0.5 0.5 50 1 0 0 0
1 0.5 0.5 0.5 0.1 0.1 0.1 0.1 0.1 0.1 200 0.7 0.8 0.8 0.8
1 0.9 0.2 0.2 0.99 0.99 0.99 0 0 0 0 0 0 0 0
<NL>
Objects
5 1 1.0 0 0 0 15 15 15  - Polygon
4 1 2 3 4
<NL>
1 0 1
1 0 -1
```

```
-1 0 -1
-1 0 1
<NL>
2 2 1.0 0 2 0 7 2 3     - Parallelipiped
2 3 1.5 0 5 10 3 5 3    - Parallelipiped
1 4 1.0 7 15 -7 3       - Sphere
<NL>
Textures
2 1 2 0 0 0 0 2 0 0 0 0 2 0 0 0 0 1 0.4 4
4 2 5 0 0 0 0 5 0 0 0 0 5 0 0 0 0 1
5 4 10 0 0 0 1 10 0 0 1 1 10 0 0 0 0 1 0 0.6 0.5 2 0.1 6
<NL>
Demo / 11-OCT-1989 / Antonio Costa
[End of File]
```

To ray trace without textures, do:

```
  rtrace demo.sff demo.pic >&demo.log
```

else, do:

```
  rtrace t2 demo.sff demo.pic >&demo.log
```

Another example with INESC symbol:

```
[Start of File]
View
45.0 45.0 81.0  - Eye point
45.0 45.0 -81.0 - Look point
 0.0  1.0  0.0  - Up vector
30 30           - View angles
Colors
0.196 0.6 0.8 - Background (Sky Blue)
0.3 0.3 0.3   - Ambient
Lights
1  0.0 100.0 100.0 1 1 1 - Light 1 (White)
1 90.0 100.0 100.0 1 1 0 - Light 2 (Yellow)
<NL>
Surfaces
1 0.557 0.420 0.137 0.8 0.7 0.7 0.2 0.3 0.3 30 0.8 0 0 0
1 0.137 0.420 0.557 0.5 0.5 0.6 0.5 0.5 0.4 5 0.2 0 0 0
1 0.600 0.800 0.200 0.9 0.9 0.9 0.0 0.0 0.0 1 0 0 0 0
<NL>
Objects
1 1 1.0 10.0 09.5 0.0 4.5 - Sphere
1 1 1.0 10.0 26.5 0.0 4.5
1 1 1.0 20.0 63.5 0.0 4.5
1 1 1.0 20.0 80.0 0.0 4.5
1 1 1.0 40.0 09.5 0.0 4.5
1 1 1.0 40.0 26.5 0.0 4.5
1 1 1.0 40.0 43.5 0.0 4.5
1 1 1.0 50.0 80.0 0.0 4.5
1 1 1.0 60.0 53.0 0.0 4.5
1 1 1.0 70.0 09.5 0.0 4.5
1 1 1.0 70.0 43.5 0.0 4.5
4 2 1.0 10.0 30.0 0.0 1.5 10.0 70.0 0.0 1.5 - Cylinder
1 2 1.0 10.0 70.0 0.0 1.5
4 2 1.0 10.0 70.0 0.0 1.5 17.5 77.5 0.0 1.5
4 2 1.0 12.5 12.0 0.0 1.5 20.0 19.5 0.0 1.5
1 2 1.0 20.0 19.5 0.0 1.5
4 2 1.0 20.0 19.5 0.0 1.5 20.0 60.0 0.0 1.5
4 2 1.0 22.5 61.0 0.0 1.5 37.5 46.0 0.0 1.5
4 2 1.0 37.5 12.0 0.0 1.5 30.0 19.5 0.0 1.5
1 2 1.0 30.0 19.5 0.0 1.5
4 2 1.0 30.0 19.5 0.0 1.5 30.0 33.5 0.0 1.5
1 2 1.0 30.0 33.5 0.0 1.5
4 2 1.0 30.0 33.5 0.0 1.5 37.5 41.0 0.0 1.5
4 2 1.0 30.0 26.5 0.0 1.5 36.5 26.5 0.0 1.5
4 2 1.0 40.0 47.0 0.0 1.5 40.0 70.0 0.0 1.5
1 2 1.0 40.0 70.0 0.0 1.5
4 2 1.0 40.0 70.0 0.0 1.5 47.5 77.5 0.0 1.5
4 2 1.0 42.5 12.0 0.0 1.5 50.0 19.5 0.0 1.5
1 2 1.0 50.0 19.5 0.0 1.5
4 2 1.0 50.0 19.5 0.0 1.5 50.0 43.0 0.0 1.5
1 2 1.0 50.0 43.0 0.0 1.5
4 2 1.0 50.0 43.0 0.0 1.5 57.5 50.5 0.0 1.5
4 2 1.0 67.5 12.0 0.0 1.5 60.0 19.5 0.0 1.5
1 2 1.0 60.0 19.5 0.0 1.5
4 2 1.0 60.0 19.5 0.0 1.5 60.0 33.5 0.0 1.5
1 2 1.0 60.0 33.5 0.0 1.5
4 2 1.0 60.0 33.5 0.0 1.5 67.5 41.0 0.0 1.5
5 3 1.0 0.0 4.0 0.0 200.0 200.0 200.0 - Polygon
4 1 2 3 4
<NL>
 1.0 0.0  1.0
 1.0 0.0 -1.0
-1.0 0.0 -1.0
-1.0 0.0  1.0
<NL>
<NL>
End
INESC Logo / 23-FEB-1989 / Antonio Costa
```

HISTORY

25-Jul-92 Antonio Costa at INESC-Norte
Release 7.3.1
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